An Assessment of Information Systems Capabilities Required To Support U.S. Materials Policy Decisions

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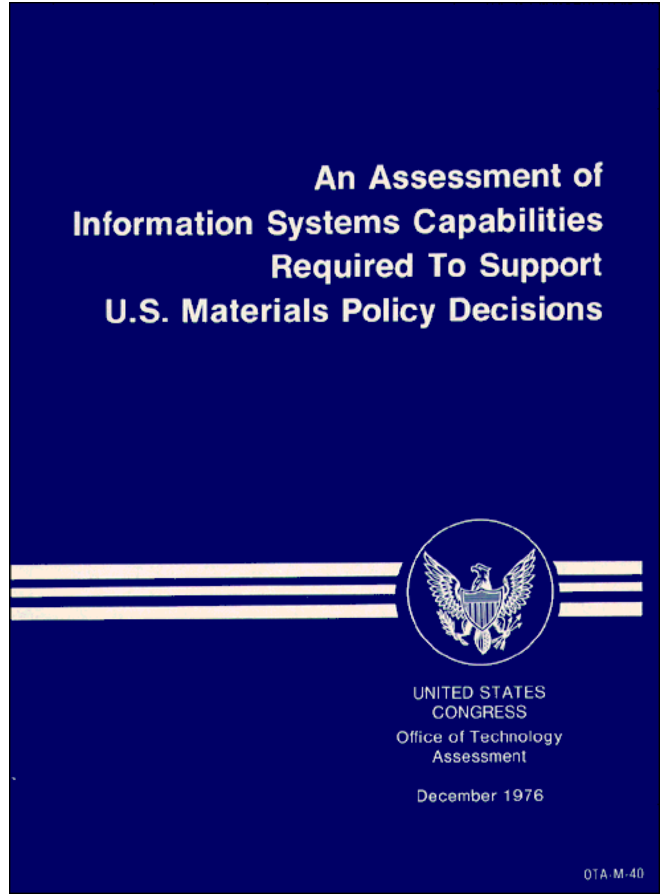

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Congress of the United States
OFFICE OF TECHNOLOGY ASSESSMENT
WASHINGTON, D.C. 20510

DEC 1 - 1976

Committee on Science and Technology
U. S. House of Representatives
Washington, D. C. 20515

Gentlemen:

On behalf of the Board of the Office of Technology Assessment, we are pleased to forward a report: An Assessment of Information Systems Capabilities Required To Support U.S. Materials Policy Decisions.

The report concludes OTA's analysis of the need for improving the Government's information systems to support policymakers. It specifically outlines possible improved capabilities, alternative approaches to implementation, institutional changes needed for implementation, and an analysis of possible impacts resulting from establishing the improved capabilities.

This assessment was performed in accordance with your request to the Office of Technology Assessment dated December 13, 1974. An earlier summary of this report was transmitted to the Committee in February 1976.

Sincerely,

Olin E. Teague
Chairman

Sincerely,

Clifford P. Case
Vice Chairman

Enclosure

Congress of the United States
OFFICE OF TECHNOLOGY ASSESSMENT
WASHINGTON, D.C. 20510

EMILIO Q. DADDARIO
DIRECTOR
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DEC 1 - 1976

The Honorable Olin E. Teague
Chairman of the Board
Office of Technology Assessment
Congress of the United States
Washington, D. C. 20515

Dear Mr. Chairman:

The enclosed report, An Assessment of Materials Information Systems Capabilities Required To Support U.S. Materials Policy Decisions, presents OTA's assessment of alternatives for providing essential information and analyses in support of materials policy.

The assessment was requested by the Chairman and the Ranking Minority Member of the House Science and Technology Committee. In both the 93rd and 94th Congresses, more than a dozen bills aimed at correcting perceived deficiencies in current materials information systems were introduced. Two general themes run through these bills. One is that reliable information is essential to sound policymaking, the other is the belief that modern technology for handling information provides the means to improve existing systems.

The following report: 1) delineates the need for improving existing materials information systems; 2) describes possible improved capabilities to address shortage-related policy problems; 3) outlines alternative approaches for implementing the improved capabilities, including alternative institutional arrangements; and 4) assesses the possible impacts and public policy issues that may arise with the implementation of such system improvements.

The results of this assessment have been used extensively by the National Commission on Supplies and Shortages. The Commission has been urged by the Majority and Minority Leaders of the Senate, Senators Mansfield and Scott, to focus its efforts on determining "what institutional adjustments (including even establishing an agency) are needed in the Nation to provide a coordinated strategic economic information system and to analyze economic needs (for resources, commodities, materials, and manufactured products) on a permanent basis. . . . " The OTA assessment analyzes such adjustments, and concludes that they would be feasible and warranted.

During the course of the assessment, OTA presented information and analyses in hearings held by 1) the Senate Commerce Committee regarding the "National Resources and Materials Information Act," and 2) the Senate Interior and Insular Affairs Committee regarding a bill to establish a "National Energy Information System."

Sincerely,

EMILIO Q. DADDARIO
Director

Enclosure

PREFACE

This assessment is an analysis of materials information systems and their capability to support effective policymaking decisions on materials problems. The assessment is one element of a broad consideration of materials-related problems being undertaken by the Office of Technology Assessment (OTA) in response to various congressional requests.

In responding to these requests, OTA has used the unifying concept of the total materials cycle to tie the individual requests into a totally integrated approach. Related projects cover various phases of the total materials cycle and include mineral accessibility on Federal and non-Federal lands: exploration technology; recovery of commodities from subeconomic resources; stockpiling; resource recovery and recycling; materials conservation; substitution to reduce import dependency; and strategies, policies, and decision mechanisms for dealing with resource problems.

The request for a materials information assessment was submitted by the House Committee on Science and Technology. Specifically, the Committee asked for an analysis of ". . . the adequacy of present materials information systems for the technology of materials supply, processing, and uses. . . ." While the assessment is in response to the House Committee on Science and Technology, it also addresses the interests expressed in a letter from Senators Mansfield and Scott to the National Commission on Supplies and Shortages. Their letter, dated November 19, 1975, stated that the Commission should focus its efforts on a determination of "what institutional adjustments (including even establishing an agency) are needed in the Nation to provide a coordinated strategic economic information system and to analyze economic needs (for resources, commodities, materials, and manufactured products) on a permanent basis. . . ."

This report was prepared by the Office of Technology Assessment materials program staff, under the supervision of Drs. Albert E. Paladino and John B. Wachtman, with contributions from: (1) a materials advisory committee comprised of individuals drawn from the materials field, academia, labor, public interest groups, and private industry; (2) several private contractors; as well as (3) numerous other private and public agencies. The materials advisory committee provided advice and comment throughout the assessment, but does not necessarily approve, disapprove, or endorse the report, for which OTA assumes full responsibility,

The Technology Assessment Board approves the release of this report, which identifies a range of viewpoints on a significant issue facing the U.S. Congress, The views expressed in this report are not necessarily those of the Board nor of individual members thereof.

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SUMMARY

A. BACKGROUND

The processing and use of materials account for almost 50 percent of the U.S. Gross National Product, some $576 billion. In 1973, materials-oriented sectors employed over 34 million workers—45 percent of the full-time work force. In 1973, these sectors consumed over 80 percent of the total value of all U.S. imports. Significantly, materials imports have been rising since 1967, and there have been periodic scarcity-related situations since the 1950's. But it was not until the 1973 oil embargo that many people realized the United States could in fact run short of some vital materials, especially those from foreign sources of supply.

To address emerging problems, and to provide materials at reasonable prices throughout the mine-to-consumer process requires effective management, and effective management in turn requires a broad spectrum of information and analysis. Scientists and engineers need technical data[2] on materials properties and processes. Businessmen need information on materials supply and demand. Government policy makers need information and analysis to decide whether emerging materials problems can be solved by the existing market system or whether some type of Government action in support of the market is required.

In response to the need for effective management as well as for timely information and analysis, a large number of formal and informal materials information systems have been developed, both in the public and private sectors. Table 1 indicates the diversity of materials activities in just the public sector which depend upon these systems for information and analysis.

These information systems have served the Nation well for many years. However, new issues, like those surrounding the availability of imported materials. have raised questions regarding their continuing effectiveness. Not only are concerns about potential scarcities and outright shortages intensifying, but policy makers must deal today with a wide range of difficult and interrelated questions for which existing information systems were not developed. For example, will a shortage in a particular critical material develop and when ? Where will the impact be felt most severely ? How might affected industries ease the resulting economic distortions? What policy options (stockpiling. conservation, substitution, expanded production capacity, export controls. import tariffs, price controls, subsidies. research and development grants. Federal land leasing. etc.) might be adopted?

[1]Materials have been defined in a number of ways. including: "Natural resources intended to be utilized by industry for the production of goods. with the exclusion of food". (This definition is taken from Title II of Public Law 91-512. the Resources Recovery Act of 1970.) Another definition that is suggested when using materials is the modern sense of addressing the "Materials Cycle". It is an all-encompassing one. Frank Huddle defines "materials" in *Science Policy: A Working Glossary*. as "the stuff that things are made of or with. or could be".

[2]As used here. data are specific facts—usually numerical. quantitative. and measurable. Examples are the properties of materials. the populations of cities. and the dimensions of land masses. Being primarily numerical, data are fairly readily stored and manipulated in automated systems. Information is the broader class of knowledge. encompassing judgments experience. art. behaviorial considerations. etc. Examples include directions on how to do something, expressions of policy, social considerations, esthetics, alternatives. Because it is expressed in words, the broader aspects of 'information' are more difficult to mechanize. Data are a category of information. These considerations are significant when one contemplates the implementation of an automated information system.

Table 1: Selected Examples of Government Materials Activities

Policymaking Activity	Examples of Agencies Currently Involved
Support to domestic production	DOD, GSA, ERDA, NBS, Bureau of Mines
Development of new materials	DOD, Bureau of Mines, Forest Serv , ERDA, NSF, EPA, FEA, DOI, DOA, CEQ, DOC
Conservation, substitution, and recycling of materials.	EPA, FEA, DOI, DOA, CEQ, DOD
Data collection and analysis.	DOA, Bureau of the Census, Tariff Comm,, Bureau of Mines, U.S. Geological Survey
Policy, planning, and coordination.	Congress, DOA, DOI, OMB, CEA
Control and regulation activities.	Ofs. of Export Admin., Nuclear Regulatory Agency, MESA, DOA
Monitoring of international activities. , ...	Department of State, DOA, DOC
Fiscal monetary and trade actions	Dept of Treasury, CEA, FRB, DOA

Adapted from: Meyer J. Harron and John D. Crawford, Government *Materials Activities,* Washington, D. C.: Federal Preparedness Agency, July 1975

Finally, each question must be considered within the context of specific materials properties and characteristics, as well as changing domestic and international political situations.

B. SCOPE AND OBJECTIVES

The purpose of this assessment is to provide background and analysis so that Congress can consider: (1) how adequate existing materials information systems are in supporting governmental policymaking, particularly in regard to potential scarcities or outright shortages; (z) what improvements, if any, are needed to furnish policy makers with the information and analysis they need to deal with scarcities or outright shortages, and (3) what impacts, if any, might stem from such improvements.

In contrast with past studies which considered only isolated aspects of materials information, this assessment addresses materials information in a comprehensive manner by looking at the demand, supply, and other related factors influencing materials flow throughout the materials cycle—from exploration, mining, production, utilization, and recycling to eventual disposal.

The assessment was thus organized and conducted to address the following questions:

- Are information systems which currently support Federal materials policymaking adequate to address complex materials problems?
- If the systems cannot provide the needed capabilities, what kind of improvements are required ?
- How might these improvements be achieved—by what organizational authority, and under what kinds of institutional arrangements?
- What impacts, if any (institutional, economic, social, international, and legal), might result from implementing such improvements?
- Finally, what public policy issues might accompany such improvements, if implemented?

C. IMPROVEMENTS REQUIRED IN EXISTING MATERIALS INFORMATION SYSTEMS

In view of the growing importance of materials issues and the role of public policy in dealing with them, existing materials in formation systems were found to be inadequate to support Federal policy makers responsible for anticipating and coping with scarcities or outright shortages. The assessment found that some of the analytical and coordinative functions needed to address these new issues were performed inadequately; some not at all. It should be emphasized, though, that these limitations result not so much from a lack of data, as from the stringent requirements for information management, analysis, and coordination associated with the increasingly complex problems now facing policy makers. In particular, the Government's materials information services are limited in their ability to address issues of supply and demand because they are neither organized or managed within a comprehensive, integrated framework,

The following inadequacies in existing materials information systems were identified:

- Lack of consistent, standardized data definitions and formats, which inhibit aggregation of data, analysis, and exchange among users (often an interested official does not know that the information he seeks exists, or if he does know, where it can be found in another agency, differences in format and definitions often make it hard for him to understand the data);
- Incomplete coverage and lack of current data bases, particularly with respect to data on foreign resources, reserves, production, and consumption;
- Inadequate analytical models and techniques for projecting the effects of changes in supply and demand;
- Reporting formats that do not meet the practical needs of decisionmakers; and
- Inability to respond quickly to complex, policy-oriented questions.

These shortcomings apply in varying degrees to most existing systems, However, they are more evident in those systems handling nonrenewable resources, where responsibility is shared by a larger number of agencies, than in those systems which handle renewable resources like timber and natural fibers.

In order to improve current Government materials information systems, it is not sufficient merely to develop new, or improve existing, data gathering and analysis functions: they must be organized and operated within an integrated framework. Such a framework could enable policy makers to understand and evaluate the principal factors influencing materials supply and demand in their proper perspective. While these improvements wouId be designed to address specific problems concerning scarcities and materials shortages, they could also be used to address the complete spectrum of materials-related issues.

The following analytical functions were identified through a detailed literature search and an extensive series of interviews as being basic requirements for Federal decision makers responsible for addressing materials policy:

- Monitoring and projecting inventories of resources and reserves;
- Monitoring and projecting the status of industrial stocks as well as strategic and economic stockpiles;
- Monitoring and projecting imports and exports;
- Monitoring and projecting the status of recycled materials;
- Monitoring and projecting quantities of materials produced and available production capacity;
- Monitoring and projecting quantities of materials consumed in end products;
- Forecasting supply
- Forecasting demand; and
- Forecasting the interaction of price, supply, and demand.

Of course, other analytical functions could be added to the basic set listed above to provide a more comprehensive assessment of policy alternatives, covering such considerations, for example, as the possible impacts on the materials cycle of changes in availability of transportation, trained personnel, and capital.

Implementing these analytical functions within an integrated framework could provide the improved capabilities to indicate what quantities of material are likely to be produced and used at each stage of the materials cycle, The Government policy makers could then use these improved capabilities to decide whether or not the market could absorb the impacts of scarcities or outright shortages. If it could not, and unacceptable dislocations in the economy might occur, then the improved capabilities could be used to test the effectiveness of alternative Government responses in averting or alleviating the scarcity or shortage situation.

These improved capabilities will not be realized by simply allowing existing systems to evolve, however, these systems do constitute a strong base on which to make improvements, Some of the current systems, in particular those used for forecasting agricultural food and fiber commodities, have been in development for over 40 years. Other systems, covering minerals and metals, are rapidly undergoing improvement; in fact many of the existing systems are either performing or could be performing some of the necessary monitoring and projecting functions identified above.

D. OPTIONS FOR IMPROVING MATERIALS INFORMATION CAPABILITIES

Four possible options for providing materials information systems capabilities were identified and assessed as follows:

1. Evolution of Current Systems Without Direct Action

The first option available to Congress and the President is to do nothing, that is, to let current materials information systems continue to evolve without direct intervention. This option assumes that such existing limitations as the lack of consistency or standardized data definitions and formats would be resolved in time to deal effectively with emerging issues.

2. Legislative Branch Options Short of New Authorizing Legislation

Congress could take a number of possible options short of legislation to provide various kinds of improved materials information and analysis. First, Congress has the ability to act through existing congressional offices and agencies which already have a general mandate compatible, at least in part, with the need for improved materials information and analysis. Second, Congress has the ability to provide improved materials information via the executive branch through congressional hearings, exercise of oversight and investigative powers, or congressional resolutions requesting executive branch action. Third, individual members of Congress can issue policy statements designed to stimulate private sector efforts toward providing improved materials information.

3. Executive Branch Options Short of New Authorizing Legislation

Another option is to make use of the power of the executive branch. First, a Presidential proclamation or policy statement—while not having the force of a law-can set an overall direction towards improving materials information. Although the President's power to issue Executive orders has been restricted by Congress, some materials information needs can also be met through Executive or agency order. Another option could involve grants and contracts to the private sector to improve information capabilities,

4. Options Requiring New Authorizing Legislation

The first three options can be implemented within the framework of existing systems and institutions, This last option assumes that some type of change in existing materials information systems is necessary. Underlying this option is the assumption that upgrading current Government materials information systems would be beneficial to the Nation in dealing with problems of materials supply and demand. While the existing information systems do constitute a base on which to build, they are fragmented and dispersed throughout the public and private sectors and are programmed for many diverse purposes.

In order to illustrate how this last option might be implemented, three possible systems approaches for implementing the improved capabilities were defined in the assessment and are discussed as follows:

(a) Systems Approach A.—The establishment of an interagency Federal committee or congressionally authorized group to standardize the formats of the current materials information systems. Under this approach, various agencies would maintain their present information systems, but improved coordination would encourage increased communication and cooperation. Agencies could be assigned additional responsibilities. such as collection of new data, which would be required to improve overall capabilities. This approach involves little, if any, organizational change.

(b) Systems Approach B.—The creation of a full-time organization to make step-by-step improvements in existing information systems and add new supplementary capabilities as required. The organization would closely monitor the development of existing systems and direct and focus activity required to improve overall capabilities. It would determine what resources were needed. compare them with present capabilities, and then fill the gaps by assuming responsibility itself or assigning it to other agencies.

(c) Systems Approach C.—The creation of a central program management office to first design the improved capabilities from the "top-down" and then implement the new design, using portions of existing information systems whenever possible. This central management group would then direct the revised Federal materials information system.

Seven institutional arrangements were identified as possible means of implementing the three systems approaches discussed above. An analysis was then undertaken to determine where the improved capabilities could be located. The possibilities of locating them in the private sector and within a quasi-governmental institution were considered; however, it was determined that the executive branch was the most appropriate location,

The seven institutional arrangements are described in table 11. To differing degrees. all of these arrangements could assist in providing the improved information systems capabilities. It should also be noted that each institutional arrangement involves progressively more authority than the preceding arrangement.

Under approach A, an interagency Federal committee or congressionally authorized group would establish a Materials Information Referral Office or a Materials Information Coordinating Board. The new groups would be located in existing agencies, most probably the Departments of Commerce or Interior, or perhaps within the Executive Office of the President. A Materials Information Referral Office would direct information queries to the appropriate information services in the public or private sectors and survey materials publications. It would, in essence, be a clearinghouse.

A Materials Information Coordinating Board would guide the operations and incremental improvements of existing information systems. The board would monitor the systems and suggest operational and upgrading guidelines. All of the board's proposals would be advisory in nature. Decision making powers would remain in the various agencies but the board would promote more uniform operation and improved cooperation between existing systems.

Table 2.—Alternative Institutional Arrangements

	1 Materials Information Referral Office	2 Materials Informal Ion Coordinating Board	3 Bureau Of Materials Statistics	4 Bureau of Materials Statistics & Forecasting	5 Materials Statistics Administration	6 Materials Statistics Forecasting Administration	7 Materials Information Commission
Location	Existing or new office within existing agency	Existing or new office within existing agency	New office with - in existing agency	New office with - in existing agency	New executive agency	New executive agency	New independent agency or commission
Parent Agency	Existing (parent) agency should afford the office sufficient opportunity to develop and/or acquire the necessary resources competence credibility. and reputation				None	None	None
Directorship	Director appointed by agency or office head	Chairman and members selected from agencies & user groups may be appointed by President	Director appointed by President with Senate advice and consent	Director appointed by President with Senate advice and consent	Administration appointed by President with Senate advice and consent	Administration appointed by President with Senate advice and consent	Commissioner appointed by President for fixed terms of office with Senate advice and consent
Source of Authority	OMB directive Executive agency order and /or Act of congress	OMB directive Executive agency order and or Act of Congress	Act of Congress	Act of Congress	Act of Congress	Act of Congress	Act of Congress
General Authority	The general scope of authority for all alternatives includes the acquisition and analysis of Information and related data processing collection support necessary for implementation of designated capabilities and options in areas relating to materials/commodities and supply utilization life cycles including secondary factors (e q labor capita I energy environment prlce techno lology and transportation) and interrelatlonships (e g between materials energy and the environment)						
		Authority to make recommendation's (and take actions to the extent possible under applicable law) for improvement of existing Federal Government materials information systems coordination and Integration of existing systems standardization of existing systems Improvement of reporting forms and data classification etc Authority to provide support for private sector development of capabilities and services necessary					
					Authority to promulgate rules and regulations to carry out the above activities		
Specific Authority Capabilities	Referral	Referral	Referral Clearinghouse Statistical	Referral Clearinghouse Statistical Forecasting analytical	Referral Clearinghouse Statistical	Referral Clearinghouse Forecasting/analytical	Referral Clearinghouse Statistical Forecast - ing analytical
Data Collection and Protect Ion	All alternatives rely primarily on the existing authorities of relevant agencies (usually a mix of voluntary and mandatory reporting) subject to existing protections of data sources and trade secrets and other proprietary confidential or privileged Information						
			Authority to require that relevant agencies submit summary data in aggregated form) to the office/agency subject to existing or new protections of data sources Authority to collect original data that is not otherwise available from existing sources				
					Authority to promulgate rules and regulations for collection of original data by other agencies		
							Authority to require that 'agencies submit detailed data
Data Validation	All alternates rely substantially on the existing authorities of relevant agencies subject to existing protections of data sources						
			Authority to use statistical techniques, sampling, and other methods of data verification and where necessary, to require submission of original data from the relevant agencies, subject to existing or new protections of data sources				
					Authority to undertake, where necessary, direct validation of materials data at the original source subject to new or existing protections		
Data Access	The Freedom of Information Act (FOIA) sets the basic guidelines for access to data in all configurations Data information not falling within an exempted category would be available to the public Congress and the President either directly from the NIMIS office agency and or in the case of Congress via the CBO (or some other lead congressional office) and for the President via OMB (or some other lead executive office)						
User Charges	The Freedom of Information Act also sets the basic guidelines with regard to user charges for public access which may be no greater than the cost of search plus reproduction In general there would be no charge for standard referral services with the charge for other services no greater than the cost of search plus reproduction Special services for other agencies or private users may be charged on cost-reimbursable or subscription basis						
Oversight	All configurations would be subject to normal oversight of OMB and congressional committees, supplemented by GAO (which would be required to maintain continuous monitoring of office/agency activities, in addition to any investigators or data validations requested by Congress)						

Under approach B, a Bureau of Materials Statistics or a Bureau of Materials Statistics and Forecasting would be established. Either bureau would be located in an existing agency, again most probably the Departments of Commerce or Interior. Both would have a materials information clearinghouse/referral service through which users could locate and obtain materials information. Both would have a statistics capability to provide summaries, trend reports, and other materials information. Both bureaus would have data processing and collection capabilities. They would supervise the development of effective information exchanges between existing agencies and build up a summary materials data base. The bureaus would verify data through various methods to insure the reliability of materials information and would facilitate improvements of needed capabilities in existing agency information systems. The Bureau of Materials Statistics and Forecasting, would, in addition, be able to produce materials forecasts and analyses,

Approach C would involve the greatest amount of change in existing systems. A new agency would be set up—a Materials Statistics and Forecasting Administration, a Materials Statistics Administration, or a Materials Information Commission. A Materials Statistics Administration could perform all the functions of a Bureau of Materials Statistics. It would also have the authority to promulgate rules and regulations to improve existing Federal systems, including rules related to data classification and verification, and to validate data at the original source. A Materials Statistics and Forecasting Administration could perform the same functions as a Materials Statistics Administration, and, in addition, would be able to generate materials forecasts and analyses. An independent Materials Information Commission could carry out the same functions as the other two agencies. It would also have authority to establish its own detailed data base which could supersede portions of existing agency data bases.

E. IMPACTS RESULTING FROM THE IMPLEMENTATION OF THE THREE SYSTEMS APPROACHES

Analysis of the three systems approaches and the seven institutional arrangements indicates that approach A, the "incremental level" of change, could result in some benefits. Establishing a Materials Information Referral Office or Information Coordinating Board could produce only minimal impacts. The office or board might promote more uniformity in existing information services and encourage coordination of agency materials policies. They could provide a central referral office which could ease difficulties in locating and obtaining information. But neither the office or the board could solve most of the problems resulting from differing agency policies, nonuniform standards, and incompatible information systems.

Of the three systems approaches, approach B, could produce the most benefits with the least cost. Overall, the impacts stemming from this approach should be positive. and possible detrimental impacts could be largely avoided , or controlled. Approach B is especially attractive because of its flexibility and adaptability to new circumstances. The step-by-step development could ensure review before each commitment was made. This arrangement would also provide continuity with few technical problems. The main task would involve setting up links between existing information services and the new referral/clearinghouse. Existing systems could continue to operate and collect data, and the new bureau could be operational within months. Its administrative authority could be strong. Financial costs could be low or high, depending, on how far the bureau could take full advantage of the investment in existing information systems. Moreover, Congress would have the opportunity to review each step before funds for expansion were appropriated, While approach B does have several potential weaknesses—the possibilities of weak budget control or the possible problems in getting access to needed expertise—the overall impacts of approach B are positive,

The assessment also concluded that under approach B the best institutional arrangement was 4. This institutional arrangement would establish a Bureau of Materials Statistics and Forecasting. The difference between arrangement 3, establishment of a Bureau of Materials Statistics, and 4, is that the latter arrangement would include the authority for producing forecasts of materials supply and demand, and further analytical support for planning and policy formulation. Also, 4 could provide a focus for the integration of existing Government materials information services. Policy makers would be able to go to a central source to be directed to the most timely and complete information and analyses. Also, other agencies and private industry could check their own projections with the forecasts issued by the bureau, Thus, contingency planning for materials shortages could be improved, The forecasting and analytical capabilities of such a bureau could provide more consistency in the long-range planning of agencies and Congress. Potentially, there could be a broader consensus on materials-related issues, With improved analysis, policy makers could be able to better handle shortage situations and plan for possible future scarcities, especially those related to the Nation's growing dependency on foreign source materials.

In the private sector, improved forecasts and analysis from such a bureau could aid industry in its long-range planning. The centralized functions of the bureau could provide a focal point for Government-industry cooperation in developing and carrying out materials policies. Access to more comprehensive and timely materials information could affect competition. Business could better select from among various materials substitutes. New information could lead to more efficient production processes, more effective allocation of resources, and improved products. If such new products last longer and are more useful, the quality of competition could be enhanced and scarce resources conserved.

Information and analysis from such a bureau might point to areas where savings could be made and profits realized. Research and development priorities could be altered; activities could be expanded in areas where resources are available and reduced in those where key materials are short. Industrial R&D could increasingly focus on ways to reduce waste and recycle materials or develop substitutes. The result could be lower costs. Smaller firms lacking analytical and data-gathering capabilities could benefit. If better data were accompanied by analysis, smaller companies could improve their competitive positions relative to large corporations.

Trend projections and analyses from such a bureau could aid States and localities with their materials problems, especially smaller States and localities which lack information capabilities, The increased availability of information could be especially helpful to State and local governments in dealing with energy and land-use problems. The added convenience of obtaining information from a central source could greatly increase Federal-State cooperation in the materials area,

The greater availability of information should also increase participation by public interest and environmental groups and trade associations in the materials policy process, The easier access could improve public understanding of materials issues and could lead to more informed and valid criticism of specific policies, Approach C, which would mean a "top-down" restructuring of existing materials information systems, could result in the greatest amount of improvement and change. Most of the impacts growing from the establishment of a new agency or independent commission could be much the same as those resulting from approach B, the intermediate level of change. Many of these impacts could be highly beneficial. However, this sweeping level of change could also generate potentially significant detrimental impacts and costs.

Under approach C, administrative authority could be very strong and budget control could be total. The new agency could provide long-term continuity, but it could take years for the agency to get into operation. The dollar costs could be high, staffing could present problems, and there could also be technical problems. An information system of this scope has never been designed before; however, a successful restructuring of existing systems assumes that policy makers can precisely define the requirements of such a new system. Given the uncertainties in defining materials problems and the rapid pace of change in information technologies, this approach may involve unacceptably high risks.

Nevertheless, if approach C were chosen, it could provide an additional benefit to those generated by approach B. The new agency could have much stronger authority to validate data at the original source. Thus, the data and resulting information provided by the agency could be more complete and reliable. At the same time, this authority raises a sensitive point. Proprietary information gathered from private corporations might not be sufficiently secure because of the interconnections between computer data banks. Some technical safeguards could be built into the data bank, but additional legal safeguards might be needed.

With its greater viability, authority, and influence, a new agency like those in approach C could provide a powerful stimulus for long-range and contingency planning, both in Government and in the private sector. The agency could probably improve industry's ability to meet national materials needs through better planning and clarification of materials substitutes and R&D options, The agency's unique analytical capabilities could provide great help to policy makers in a wide range of areas—from stockpiling and materials conservation to international trade negotiations and national security affairs,

The high visibility and strong authority of approach C, however, are likely to arouse controversy over the growth of the Federal bureaucracy and the role of Government in economic and social planning. For example, benefits to State and local policy makers may be offset by distrust or resentment of Federal involvement in their affairs.

Various combinations of the three major approaches are possible, For example. a promising approach might be one that combines the stronger authority of an approach C agency. with the less risk and cost in the Step-by-step, incremental restructuring utilized by an approach B agency,

F. PUBLIC POLICY ISSUES

Some important public policy issues likely to arise in the planning, implementation, and opera t i o n of the i m proved information systems capabilities concern the relationship of the public and private sectors in providing materials information to each other.

Much of the technical data needed to implement the improved capabilities could be obtained through the highly developed information services that already collect, organize, and disseminate scientific and technical information. The corresponding services for handling information on the economic aspects of materials are less developed. Thus, much of the needed information would still have to be obtained directly from private firms, In tapping the available sources of data and formulating supplemental programs to extend them, the data acquisition program would need to improve the completeness. currency, and timeliness of the data bases: and improve the ease of access to them by encouraging uniform usage of terms and units of measure. and by promoting development of procedures for ensuring the security and proprietary nature of the data.

The assessment also examined the sources of Federal authority to gather information from the private sector and found that if the public sector required the private sector to provide specific materials information:

- Such a request would be consistent with existing, recognized Federal regulatory powers;
- It would not greatly, if at all, expand Federal authority over the materials industry; and
- The private sector could be protected from public disclosure of corporate proprietary information through adequate attention to checks and balances in system implementation.

Most of the detailed data submitted by individual companies in the private sector would be considered confidential, and would be exempt from public disclosure under the Freedom of Information Act and related Federal statutes. Additional safeguards however, could be incorporated in any legislation establishing a new Federal materials information structure or authority.

G. CONCLUSION

The conclusions that emerge from this assessment are (1) that action to improve existing Federal materials information systems is both necessary and the concepts suggested herein are technically feasible, and (2) that. under the conditions stated herein, the potential benefits of implementing the improved capabilities as defined would probably justify the financial and social costs of making such improvements.

The analysis provided in the assessment indicates that implementing the improved capabilities through systems approach B, institutional arrangement 4, could probably achieve a reasonable balance between benefits and costs. However, various combinations of the systems approaches also merit further consideration. For example, one approach that might be considered could combine the strong authority of approach C with the less risk and cost associated with the incremental changes suggested in approach B. Other external factors. which suggest more or less change, should be considered in the context of their cost/benefit tradeoffs during the course of future congressional deliberations. Any implementation of these findings should, for example, be preceded by detailed requirements and systems engineering studies.

Any of the three systems approaches described in this assessment could be expected to achieve, in varying degrees, improvements in U.S. materials information gathering and analysis, Implementing the new institutional and analytical capabilities along the lines identified in this assessment is a complex question with far-reaching implications. What is certain, though, is that the potential impacts of emerging problems require more comprehensive integrated information and analysis capabilities to support Federal materials policymaking.

Chapter 1

INTRODUCTION

Chapter 1

INTRODUCTION

The compatibility of man with his environment is fundamentally linked to his use of materials. Recent materials scarcities, growing concern with environmental degradation, and changing patterns in international supply and demand are among a host of factors which are creating new materials-related problems for which Congress and the executive branch of Government must fashion effective responses. These factors are inducing an historic shift in national industrial priorities away from energy-intensive, inefficient technologies toward conservation and more efficient use of materials and energy. To accommodate these changes, knowledge of the technological, economic, and social effects of materials management and usage is becoming increasingly important. Achieving a smooth flow of materials information from the laboratory to the designer and manufacturing engineer, developing prudent principles of materials management, establishing sound materials policies in the face of changing priorities—all of these require information services encompassing all functional aspects of materials utilization.

A. DISCUSSION OF MAJOR ISSUES

The current nationwide materials information "system" which has developed over a period of 200 years in response to evolved needs comprises thousands of disparate, loosely connected elements within industry. Government, and academic institutions. Given recent changes, as those cited above, several questions merit detailed consideration:

- Are information systems which currently support Federal materials policymaking adequate to address complex materials problems? In particular, are the systems able to project with sufficient accuracy whether a scarcity or shortage-related problem is likely to occur, estimate its con sequences, and evaluate possible Government actions to avert or alleviate the problem?

- If the systems cannot provide these capabilities, what kind of improvements are required ?
- How might these improvements be achieved ?—by what organizational authority and under what kinds of institutional arrangements?
- What impacts (institutional, economic, social, international, and legal) might result from implementing such improvements?
- Finally, what public policy issues might attend such improvements?

These are among the issues examined in this assessment.

The central question is whether Congress and the executive departments can significantly improve the quality of their decisions and their approach to setting national objectives by improving the existing materials information systems. The emphasis of the assessment is on information systems that would permit Federal policy makers to anticipate and deal more effectively with problems raised by materials shortages, either those arising in the near term, often with little warning, or those that may occur many years in the future. As developed during the assessment, the kind of information and analysis needed to deal with shortage-related situations is also applicable to a spectrum of other materials policy issues.

It was recognized at the outset of the assessment that a demonstration of the need for substantial changes in existing information systems rests upon a balanced consideration of both the likely benefits and potential costs, where benefits and costs are reckoned not only in technical and economic terms, but also in terms of their potential social, political, and legal impacts. For example. the exclusive right of data ownership of individual firms and the protection thereof must be considered against the needs of the executive departments for statistical information. It is not the intent of this assessment to resolve such issues, but rather, to examine the benefits and costs of available technical alternatives and associated issues,

Conceptually, several outcomes of such an examination can be foreseen. If it became obvious that the benefits associated with a particular upgrading approach greatly outweighed the possible disbenefits, the analysis would have demonstrated the "need" for change. Or, the converse could be demonstrated. Likely, the "need" for change would be found to turn on sensitive trade-offs among the technical, social, political, and legal issues. By revealing these issues and, to the extent possible within the resource constraints of the study, by assessing the benefits and disbenefits of alternative actions, the assessment attempts to develop a factual basis for congressional deliberations.

B. CONGRESSIONAL CONCERN FOR MATERIALS INFORMATION

An insight into the growing concern of Congress for improved materials information is illustrated by the bills on this subject introduced in the 93rd and 94th Congresses. Table I-1 compares the recent House and Senate bills with information needs indicated. The bills suggest problem areas in data acquisition, data handling, data analysis, data reporting, data duplication, data completeness, both foreign and domestic, data standardization, and data reliability. They generally call for improved institutional capabilities.

Table 1-1.—Needs Identified in Major Materials-Related Legislation

Information Management Needs	93rd Congress													94th Congress													
	Senate													Senate							I-louse						
	S 424	S 1283	S 2296	S 2782	S 2806	S 2966	S 3528-3467	H R 15781	H R 16008	H R 907	H R 1014	H R 9597	H R 598	S 26	S 32-S 79	S 1410	S 1415	S 1795	S 1864	Misc	H R 968	H R 1668	H R 1847	H R 2363	H R 2385	H R 9212	H Res 31
New or improved institutional arrangements		x		x		x	x			x		x	x	x	x	x	x	x	x	x	x	x				x	x
New or Improved system																											
Data acquisition	x	x		x		x		x	x				x			x	x	x	x	x	x		x	x	x		
Data handling		x		x	x	x							x			x	x	x	x		x			x	x		
Data analysis	x		x	x	x	x							x			x	x	x	x	x					x		
Reporting		x		x	x	x	x						x			x	x	x	x		x						
Duplication of data													x				x	x	x								
Completeness of domestic data				x					x							x	x		x		x		x				
Completeness of foreign data				x												x	x		x		x						
Standardization of data reports				x									x			x	x	x	x		x				x		
Reliability accuracy of data									x				x			x	x		x		x						

Examination of the bills further indicates that such materials information problems as coordination, compatability, and dissemination limited the analysis of materials shortages and related environmental problems and imbalances. Furthermore. because materials data collected by various Federal agencies were considered incomplete, incompatible. and inaccurate. the proposed legislation included recommendations for improving the regular collect ion. standardization,analysis, and reporting of such data. Attention was called to the long-term availability of critical products, materials. and resources essential to industry and commerce. as well as to the serious problems associated with the alleviation of short-term dislocations.

Most recently in the second session of the 94th Congress, hearings were held by the Senate Interior and Insular Affairs Committee to discuss the Energy Information Act. S. 1864. The bill, if passed, would assure the United States of accurate energy data with which to make decisions. Although the hill deals with fuel minerals, the materials information problems were similar to those of the nonfuel minerals discussed in this report.

Inherent in the proposed legislation was the implication that automatic data processing technology will contribute to improving the existing materials information system. However. there was uncertainty regarding the selection of the functions requiring improvements and mechanisms for improvement of automat ion.

C. ASSESSMENT APPROACH

The primary focus of the assessment is on materials information systems capabilities that could permit Federal policymakers to deal more effectively with non-food materials-related problems, Toward this objective the assessment is structured to achieve the following tasks:

1. Examination of existing materials information systems,

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2. Analysis of the capability of the current Federal information systems to support materials policymaking;

3. If required, development of improved capabilities to support Federal materials policymakers:

4. Review selected Federal information systems to examine which of the improved capabilities are either now being achieved or planned:

5. Examination of alternative approaches and institution al arrangements for implementing the improved capabilities;

6. Analysis of the possible impacts of implementing the improved capabilities: and

7. Discussion of the major public policy issues concerned with improving the Federal materials information systems.

The study draws extensively on prior studies, particularly the Paley report, Resourccs for Freedom, 1952; the report of the National Commission on Materials Policy. Materials needs and the Environment. Today and Tomorrow, 1973: and the General Accounting Office report, U.S. Actions Needed to Cope with Commodity Shortages, 1974 The Committee on the Survey of Materials Science and Engineering Report, 1974; as well as many conference summaries and reports dea1ing with specific materials,

The analyses also reflects the results of a series of over 300 interviews with information specialists and policymakers responsible for making materials-related decisions,

Chapter II

INFORMATION REQUIREMENTS OF THE U.S. MATERIALS SYSTEM

Chapter II

INFORMATION REQUIREMENTS OF THE U.S. MATERIALS SYSTEM

The dominant characteristics of the U.S. materials system is that it is a private system in which supply, demand, and allocations are largely determined by independent decisionmakers working through the market. In the past, Government action to complement the market's response to materials problems was minimal. This condition may be changing; many new pressures on the materials system are national and international in scope and transcend the decisionmaking capacity of the private sector. For Government materials policy to be effective, it must be based on an up-to-date understanding of the market forces and on timely, accurate information depicting its principal supply and demand parameters.

A wide variety of diffuse and disparate information systems in Government, industry, and academic institutions now provide guidance on all aspects of materials to decisionmakers. In contrast to a "national" system—which implies coordination and integration—these separate systems are better regarded as a "nationwide" information resource.

A. INTRODUCTION

In order to comprehend how information affects the flow of materials through the U.S. economy, one must be aware of the structure of the Nation's materials system and of the process by which materials decisions are made. Accordingly, this chapter presents an overview of the breadth and complexity of the materials information systems that have evolved to support materials decision making, including systems in the private sector, academic institutions, and Government.

Three topics are covered in this chapter:

a. The variety and importance of materials-related activities in the U.S. economy:

b. The diversity of materials decision making: and

c. The structure and characteristics of existing information systems in support of such decision making.

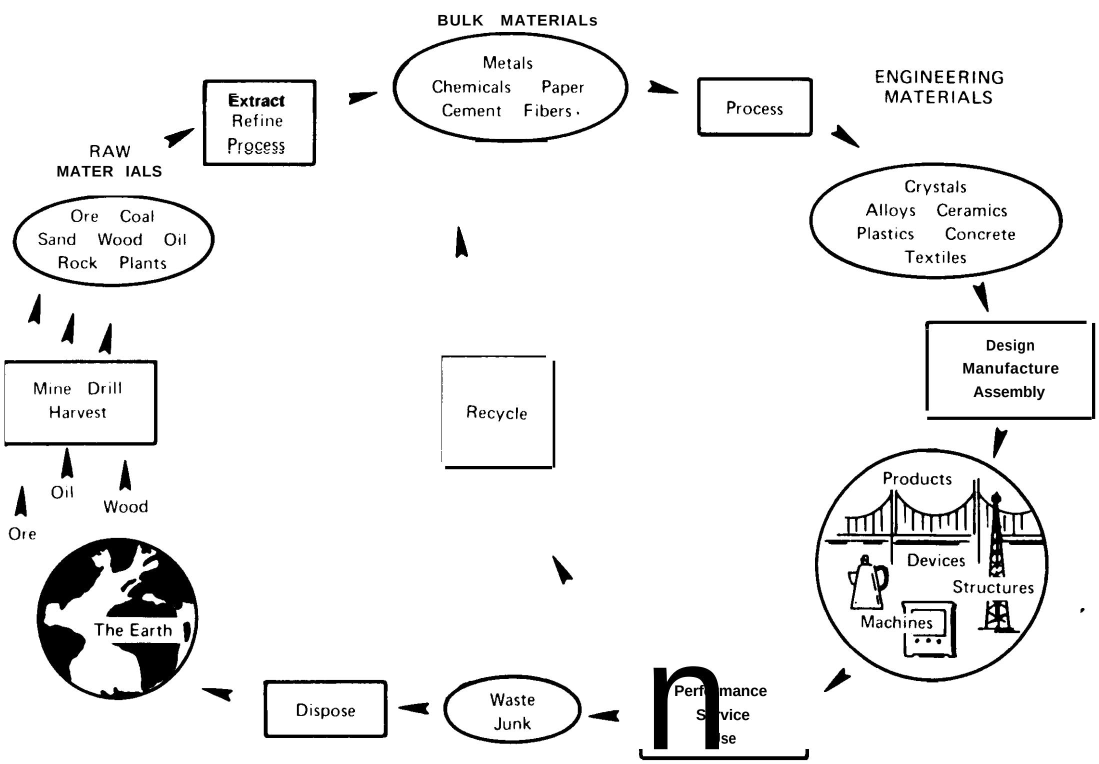
B. MATERIALS IN THE U.S. ECONOMY

The essential characteristic of the U.S. materials system is that it is predominantly a private system. It comprises many small and large firms, each making its own judgments and management decisions i n determining how materials move through the materials cycle from raw state, through processing and manufacturing, distribution, and finally, to scrap or recycling. Figure II-1 depicts this cycle. Prospectors determine where to explore; miners decide what techniques to use for the extract ion of ore and where to locate refining facilities; manufacturers determine which of several materials to use in a planned product, weighting cost versus material qualities: consumers decide whether to buy a product at the proffered price: and potential entrepreneurs determine whether to set up new services, such as a scrap and recycling business.

Table II-1 provides some evidence of the size and importance of the materials-oriented activities in the [J. S. economy (the data are for 1973):

- These activities accounted for $576 billion or almost 47 percent of the total Gross National Product (GNP),
- The value of the materials produced/consumed by the materials-oriented sectors account for over 80 percent of the Nat ion’s exports and imports.
- Over 34 million Americans were employed-45 percent of the total number of full-time workers in the labor force.
- Of the 1.9 million scientists, engineers. and technicians employed by industry, 97 percent had materials-related specialties,

Figure II-I. Materials Cycle



Source: Committee on the Survey of Materials Science and Engineering, Materials and Man’s Needs, Washington, D, C.: National Academy of Science, 1974.

Table 11–1.—The Materials-Oriented Sectors of the Economy

ITEM A

MAJOR GROUPINGS OF U.S. ECONOMIC ACTIVITIES

Industry	Materials-Oriented Elements
Agriculture, forestry, and fisheries	Forestry and non food Agriculture
Mining	All
Contract Construction	All
Manufacturing	All, except food, feed, and tobacco
Transportation	Freight and pipeline
Communication	None
Electric, gas, and sanitary services	None
Wholesale and retail trade	All, except food, feed, and tobacco
Finance, insurance, and real estate	None
Services	Higher education— forestry, engineering, and physical sciences

ITEM B

CONTRIBUTION OF MATERIALS-ORIENTED SECTORS TO GROSS NATIONAL PRODUCT

Billion Current Dollars

	1973	1980
Forestry	1.6	1.3
Mining	19.5	34.5
Construction	61.8	60.4
Manufacturing	297.7	637.2
Transportation, Utilities	47.3	94.2
Trade	148.6	256.2
Education	.3	.4
Total Materials	576.8	1,084.2
GNP	1,294.9	2,156.2
% Materials	46.7	50.3

ITEM C

MATERIAL EXPORTS and IMPORTS

Million dollars

Exports	1967	1973
Materials	25,961	56,265
U.S. Total	31,238	70,223
% Materials	83	80
Imports		
Materials	21,872	59,170
U.S. Total	26,889	69,121
% Materials	81	86

ITEM D

EMPLOYMENT IN THE MATERIALS-ORIENTED SECTORS

Millions of Employees

	1973	1980
Forestry		.1
Mining	.6	.7
construction	4.0	4.9
Manufacturing	18.4	20.6
transportation, Utilities	1.6	1.9
Trade	9.6	14.7
Education		
Total Materials Employment	34.2	42.9
National Employment	75.9	101.2
% Materials	45.1	42.4

ITEM E

ESTABLISHMENTS WITHIN THE MATERIALS-ORIENTED SECTORS

Thousands

	1973	1980
Forestry	12	15
Mining	90	110
Construction	980	1,110
Manufacturing	322	330
Transportation, Utilities	145	149
Trade	1,899	2,233
Education	2	2
Total Materials	3,450	3,949
U.S. Total	12,759	14,113
% Materials	27	28

Source Office of Technology Assessment

- There were nearly 3.5 million materials-oriented establishments.
- There were some 250 labor unions, about 1,700 business associations, and some 800 scientific, engineering, and technical associations.
- More than 200,000 academic degrees related to materials studies were awarded, representing about 17 percent of the total number of degrees conferred that year.

C. MATERIALS DECISIONMAKING

As materials move through the materials cycle—from raw state, through processing and manufacturing, distribution, and finally, scrap or recycling-countless decisions need to be made. So accustomed are Americans to the widespread availability of material products that the complexity of these decision processes is not generally recognized.

1. Decisionmaking Complexity

The complexity of decisionmaking can be emphasized by examining the flow of materials among the major segments of a specific materials industry. Figure II-2 depicts the flow for copper and zinc products among fabricators, suppliers, and customers. It points up the involved couplings which need to be considered when materials decisions are made. Decisions made at the supply end of the cycle in the mining and scrap businesses directly affect the primary copper and primary zinc businesses and, in turn, the brass castings and other industries shown. At the other end of the cycle, demand conditions and decisions of the diverse group of customers (including primary lead users) affect imports and mining.

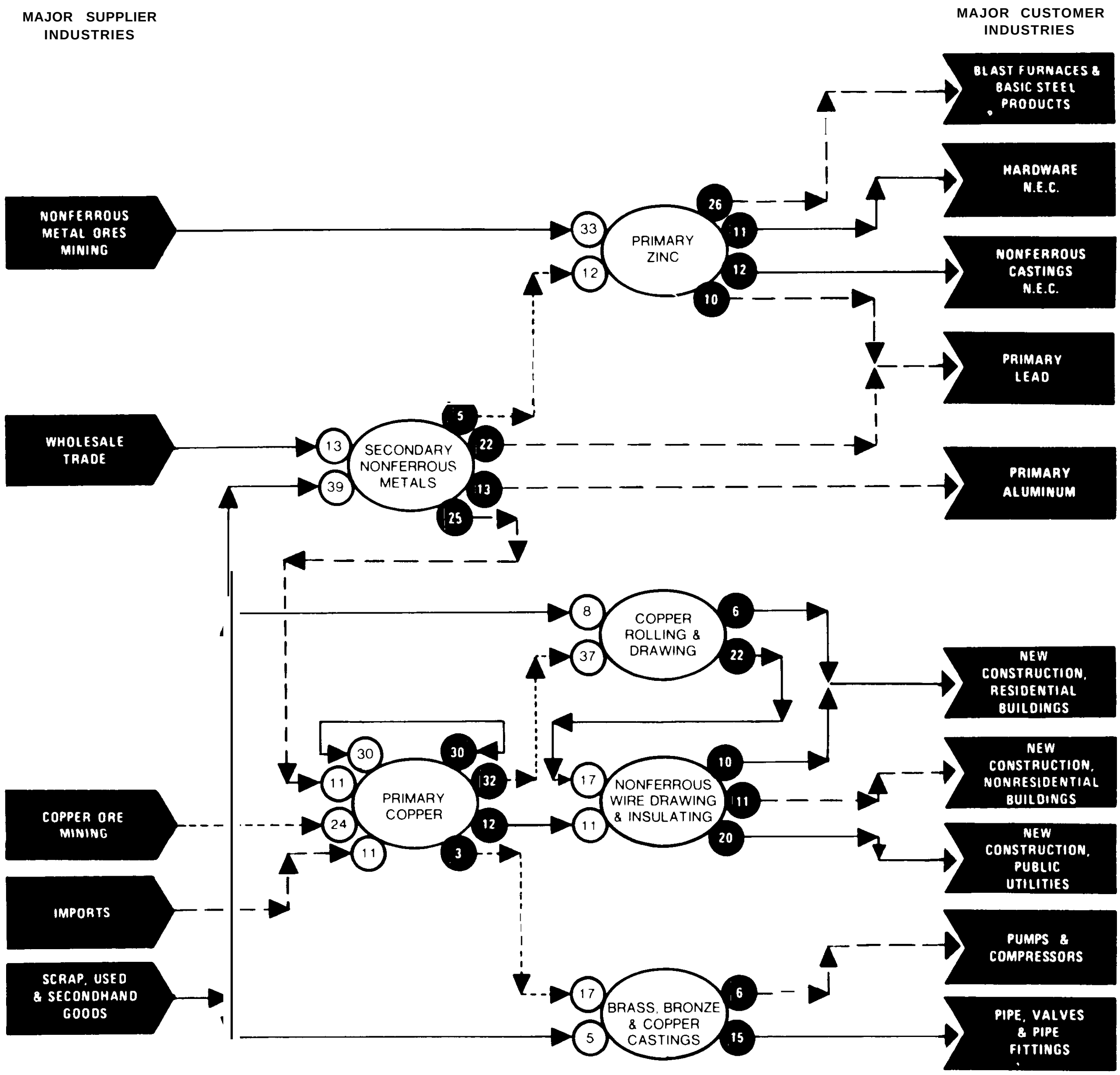
A similar example of the complexity inherent in materials decisions is shown in figure II–3 which depicts the materials cycle for aluminum. It illustrates the nature of the supply/demand interrelationships of the intermediate aluminum products from acquisition of ore to consumption of finished goods. At each stage, the supply of intermediate products is subject to and, in turn, affects the demands of the succeeding stages. Thus. various end items (automobiles, cans, household products) all compete through market forces for alum inure ingots; likewise, domestic and foreign refineries compete for the ore supply,

Guiding the decisions that control and direct the material-flow patterns in these examples and for materials generally is a body of experience and judgment that rests on the availability of information, In part, this information manifests itself automatically through the action of the market mechanism. However, when the market is unable to solve such problems. then Government materials decisionmakers may become involved. For them to make effective decisions. information on the full range of supply/demand factors and possible sectoral impacts must be available, a process discussed in the following sections.

2. Decisionmaking in the Marketplace

A fundamental advantage of the market mechanism on which the U.S. materials system now depends is the way it economizes on the need for information in reaching toward optimum allocation of resources. Sowell epitomizes this mechanism: “It has been said that nobody knows how to make (1 simple lead pencil! No single person knows how to grow the trees for the wood, mine and process the graphite for the lead, make the rubber for the eraser, extract and process the ore for the metal that holds it on, and manufacture the paint and varnish that cover the pencil. The pencil companies, of course, buy most of these materials in the market from others who do know their own small part of the process, but whose knowledge becomes very hazy and practically nonexistent as to processes a few stages ahead or behind. The alternatives available at any given stage, and

Figure II–2. Expenditures and Sales of Copper and Zinc Industries



O Percent of Copper and Zinc Industries Expenditures

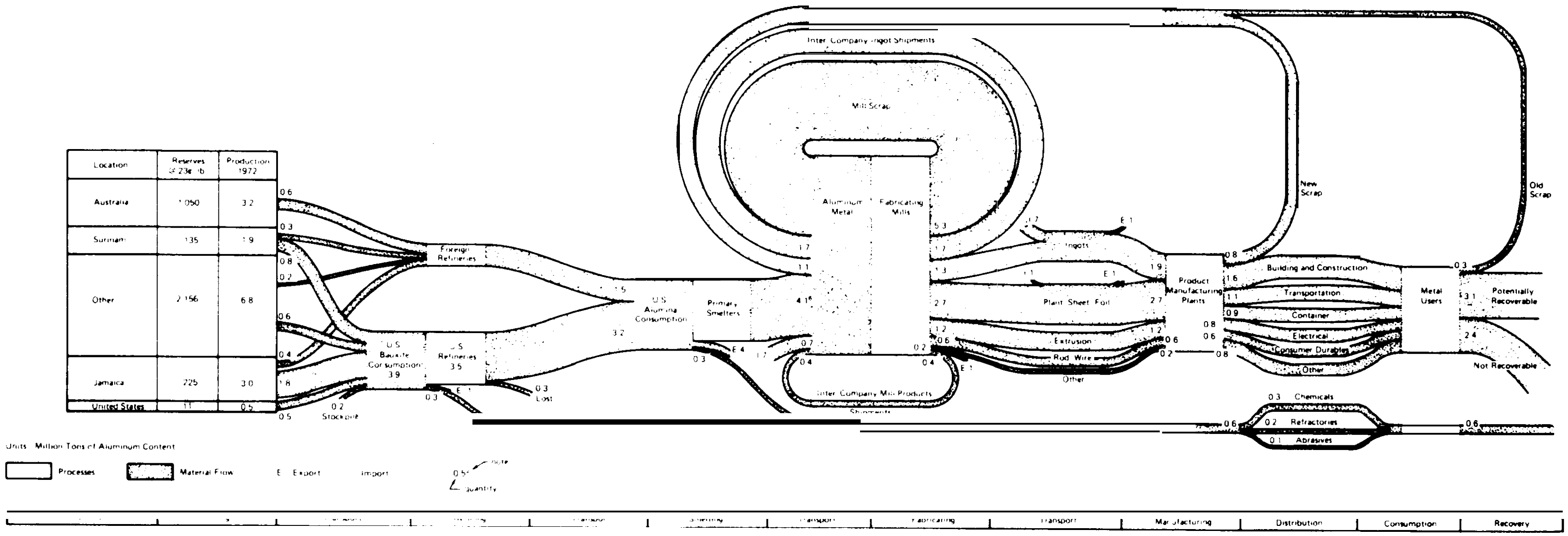
● Percent of Copper and Zinc Industries Sales

Minor Suppliers and Customers Account for percentages not Shown

See Introduction for Fuller Explanation

Source U S Department of Commerce U S *Industrial Outlook 1975* Washington D C U S Government Printing Office

Figure 3. Aluminum Cycle



the changing terms on which they are available, are likely to be fully understood only by the people at that stage. As the competition of knowledgeable people at one stage forces prices up or down in response to the underlying scarcities and technology which they understand, those further along in the process. who may not understand at all what is causing the price change. nevertheless respond to these changes so as to economize what has become more scarce. substituting what has become easier to get, increasing or decreasing their total output or changing the channels of its distribution. To achieve the same end result through a political process would require that either the public or a central planning commission have a degree of knowledge which is not needed under a price mechanism" (ref. 1).

To say that the American market system reduces the need for formally collected in formation and the amount of knowledge needed at any single decision point is not to say. however, that information is unimportant. In fact, the existence of knowledgeable buyers and sellers is one of the essential conditions for maintaining the market structure. To the extent that such knowledge is not available, the decision making structure may, at best. be inefficient: at worst. it may be incapable of coping with perturbations in materials flow.

In the United States, most materials decis ions are made by private businessmen and are based on their own projections of supply and demand. These, in turn. hinge on a wide range of subsidiary factors—technological state-of-the-art, financial conditions, international trade circumstances. and, not the least of all, Government policies as they are now understood. In recent years, particularly as many materials have come into short supply, the complexity of the decisionmaking process has been heightened and the role of Government has tended to become more important,

3. Decision making in the Federal Government

The broad range of problems posed by potential scarcities and outright shortages illustrates the growing involvement of Government in materials decisionmaking. Of concern are both short-term crisis situations exemplified by the oil embargo of 1973 and potential long-range problems such as the growing dependence on foreign sources as domestic supplies dwindle. Government attention and possible action may be required whenever shortages are projected to become so severe as to cause unacceptable distortions in the economy that cannot be addressed by the market mechanism.

In the market economy, shortages and surpluses are price-dependent. In theory, the market usually resolves them by raising prices, thereby reducing demand and increasing supply. The higher price may cause users to switch to substitutes which formerly were noncompetitive at the lower price, for exampie, copper in place of aluminum. Where acceptable substitutes are not available. use of the scarce material may be cut back; if the price rise is high enough. users may forego it completely. A similar spectrum of effects takes place on the supply side. As examples. the shortage- induced price rise could stimulate output by making unworked, lower-grade ores profitable; or it could encourage increased higher priced imports,

The need for Government action arises when a material becomes (or is projected to become) so scarce that the normal market mechanism can not prevent (or correct in reasonably timely fashion. i f at all) unacceptable distort ions to vital elements of the economy Consider. for example, a small shortfall in the nickel supply which raises the price by 10 percent. If the only users thereby denied access to nickel were nonstrategic producers (for example, toy manufacturers who could not absorb the price increase). there would not be reason for Government intervention. If the supply fell by 50 percent, however, and the resulting price rise forced producers of food machinery out of business. the problem would be of greater concern to the Government. If the supply were reduced by 90 percent. to a level that threatened defense production. the market's ability to allocate the scarce nickel on the basis of price might well break down, and governmental action could be needed to ensure vital needs and services.

In short, the principal market mechanism for allocation is price: in general. those who can afford to pay can get the scarce commod it y. Clearly, instances can arise where this criterion alone is incompatible with the public good.

The actual process of balancing supply and demand encompass a complex array of actions and is constantly at work, signaling the need for greater supplies and encouraging the most efficient ways to achieve them. Viewed from this perspective, shortages are seen to be fundamental to the market system and are neither good or bad. Examples of the wide range of normally occurring shortage-inducing factors are shown in table II–.2. Most of the factors are containable by market forces without Government intervention.

Serious shortages which could require Government action can occur for many reasons. Among the factors which could induce long-term shortages is the narrowing of relatively cheap domestic supplies of many important minerals, such as copper, lead, iron, and silver. Continued use of those materials by an expanding economy will require discovery of new deposits, development of new techniques for more efficient processing of lower grade deposits, and greater dependence on foreign sources of supply—all of which are uncertain developments, Other shortage-inducing factors result from new concerns for energy conservation and the effects of materials usage on the environment, These considerations limit the options of private decisionmakers and highlight the influence

Table n-2-Factors Tending To Diminish Supply

– A major supplier runs out of ore.
– The production system of a major supplier fails.
– Transportation breaks down between supplier and user.
– Price rise of the material causes supplier to turn to lower grade ores, which maintains throughput but lowers output.
– Capital costs rise so that maintenance of production facilities cannot be optimized and output declines.
– Facilities are diverted to removal of overburden or pockets of low yield ore and output declines.
– Operations are halted to make facility changes to satisfy safety regulations.
– Operations are curtailed to comply with environmental standards.
– Health absenteeism occurs on a major scale.
– Labor shortages occur, especially at remote sites.
– Improperly deferred maintenance occurs.
– Major accidents occur.
– Management/labor disputes occur.

Source: Adapted from F. P. Huddle, 'What Isa Shortage and What Can We Do About It?," presentation to the Society for the Advancement of Material and Process Engineering, October 1975.

Government has on the market's response. Still another factor that places some shortages beyond the reach of normal market forces is the changing situation with regard to foreign producers, the actions of OPEC being indicative.

In considering policies for any specific materials problem, the first need for Government policymaking is to anticipate which problems the market mechanisms alone are not likely to resolve satisfactorily or in a timely fashion. Once these are identified, Government policy makers can then consider a broad spectrum of responses. For example, if the shortage can be perceived early enough in terms of years, alternative sources of supply can be encouraged. Research and development programs can be emphasized to increase the productivity of domestic supplies and to find new substitutes which might be ready in time for the expected crisis. Stockpiles can be established. Policies could also be adopted to dampen demand through promotion of conservation practices or other means. However, if the shortage is near-term (or occurs without warning) and cannot be absorbed by the market, then a different range of Government responses can be invoked to supplement market forces, Past examples have included export controls, direct allocation of supplies, compulsory conservation measures (55 mph speed limit, Sunday gas station closing), price controls, and even rationing.

In general, the range of possible Government actions to deal with materials dislocations is very broad. Examples of activities and the principal agencies currently implementing them are shown in table 11–3. Table 11–4, developed by a recent National Academy of Sciences study on mineral supply, shows the possible impacts on production and consumption of a spectrum of actions that can be taken. Before any of these policies is applied, the Government policy maker must be able to

Table n-3.-Some Examples of Government Materials Activities

Policymaking Activity	Examples of Agencies Currently Involved
Support to domestic production	DOD, GSA, ERDA, National Bureau of Standards, Bureau of Mines
Development of new materials	DOD, Bureau of Mines, Forest Service, ERDA, NSF, EPA, FEA, DOI, DOA, Council on Environmental Quality, DOC
Conservation, substitution and recycling of materials	EPA, FEA, DOI, DOA, Council on Environmental Quality, DOD
Data collection and analysis	DOA, Bureau of Census, Tariff Commission, Bureau of Mines, U.S. Geological Survey
Policy, planning, and coordination	Congress, DOA, DOI, OMB, CEA
Control and regulation activities	Office of Export Administration, Nuclear Regulatory Agency, MESA, DOA
Monitoring of international activities	Department of State, DOA, DOC
Fiscal, monetary, and trade actions	Department of Treasury, Council of Economic Advisors, Federal Reserve Board, DOA

Adopted from: Meyer J. Harron and John D. Crawford, Government Materials Activities, Washington, D. C.: Federal Preparedness Agency, July 1975.

Table II-4.—Possible Government Actions in Regard to Mineral or Material Production and Consumption

Action	Impact on Domestic Production	Impact on Domestic Consumption
Financial		
Production subsidy, direct	+ to –	
Production subsidy, indirect	+	
Depletion allowance	+	
Tariff or duty on imports	+	
Federal lease bonuses and royalties	– to 0	
Government purchase and use practices	+ to –	
Exploration loans (e.g., OME)	+	
Government subsidy (including dedication of taxes) of mineral-using activities (highway, airport construction)		+
Government stockpile accumulation (domestic materials)	+	
Availability of government-identified resources	+	
Price controls	–	+
Consumer taxes		–
Production (severance, effluent taxes)	–	
Government stockpile reduction	–	
Support of materials research and development	0 to +	+ to -
Change from claim to lease system for minerals	– to +	
Incentives for foreign production	0 to –	
Depreciation	+	
Expensing of exploration costs	+	
Physical		
Import restrictions	+	
Federal land-leasing rate	+ to –	
Payment for deferred production	–	
Prohibition of production activities	–	
Zoning and withdrawal of land	–	
Prorationing	–	
Operational regulations (waste-disposal, health, land reclamation)	–	
End-use controls		–
Impurity limits (sulfur, mercury, etc.)		–
Regulations requiring building design to conserve materials		–
Regulations allowing or requiring internalization of all external or social costs of production		–
Regressive taxation of low-efficiency uses of scarce materials		–
Export controls		+

Source: Committee on Materials Policy, *Elements of a National Materials Policy*, publication NMAB 294, Washington, D.C.: National Academy of Sciences - National Academy of Engineering, August 1972.

demonstrate its need and project its consequences. For this he needs to understand how market forces operate throughout the materials cycle and to have reliable information on their current and projected status. Similarly, businessmen have need to factor into their plans the effects of possible Government actions. More than ever before, they too require quality information services and capabilities to arrive at effective actions.

This assessment is concerned with what information capabilities are required to support policy makers in the Federal Government in addressing materials-related problems. The systems in the private sector as well as in the Government that policy makers can call on were not designed for the kinds of problems expected to confront them. Rather, they evolved to meet a diverse array of public and private objectives within complex, diffuse, and pluralistic systems. Nevertheless, they represent an important national resource on which to base improvements. The structure and characteristics of these existing systems are described in the next section.

D. EXISTING MATERIALS INFORMATION SYSTEMS

There exists today a wide variety of information facilities and services with differing degrees of completeness and accuracy which support the country's materials system. In contrast to a "national" system, these information elements remain largely independent of each other. However, information from various Government, private industry, and academic locations in these systems can often be merged to address specific needs. Thus. the overall system should be regarded as a "nationwide" system—rather than a "national" coordinated and integrated system.

These existing systems were reviewed to understand how materials information is currently handled and to uncover some of the issues to be faced in deciding what improvements, if any, are needed to more effectively support materials policymaking in the Federal Government.

In its broadest context, the set of mechanisms by which people transfer, store, and use information on materials, comprises two major categories. One is the array of formal communications techniques organized around reports, handbooks, catalogs, and other documents. The other is the set of informal, largely verbal, techniques by which information is transmitted.[1] The emphasis of this assessment is on the formal systems which support policymaking decisions. However, it is necessary to recognize that in all cases policy action depends on the extraction of information from documents and other sources.

Individual information systems are varied and diffuse. as table 11–5 indicates. Like other kinds of scientific and technical information. materials information supports several kinds of activities. As elaborated in a study of the role of information services (ref. 4). these include conduct of science. generating technology and applying it in industry, public decisionmaking and policy formulation, and informing the general public. Although no simple characterization of these services is fully satisfactory. their principal components may be visualized as comprising three categories, as depicted in figure 11-4:

- Primary and Derivative Scientific and Technical Information—reports of original scientific and engineering investigations (primary sources), and compendia thereof (secondary and tertiary sources);
- Technical Trade Information—technically-oriented advertising and applications literature produced by vendor firms to promote sales; and
- Inventory and Economic Information—data and statistics characterizing the quantities and prices of materials

[1] As reported by Carlson (ref. 2) and by Wolfe (ref. 3) the informal person-to-person information channel plays a particularly important role in promoting the flow of new data and ideas among materials technologists.

Table n-5.-Examples of Elements Within Existing Materials Information Systems

GOVERNMENT	
1. Interior	13. Labor
a. Bureau of Mines	a. OSHA
b. Geological Survey	b. Bureau of Labor Statistics
c. Bureau of Land Management	14. Treasury
d. Division of Minerals Policy Analysis	a. Tariff Commission
2. Commerce	b. Office of Raw Materials and Ocean Policy
a. Bureaus of Domestic and International Commerce	15. Agriculture
b. National Bureau of Standards	a. Laboratories
National Standard Reference Data System	b. Field Service
c. Bureau of Census	c. Forest Service
d. National Technical Information Service	d. Economic Research Service
Bureau of Economic Analysis	e. Statistical Reporting Service
3. State	16. National Science Foundation
a. Desk Officers	17. NAS/NAE
b. Industrial and Strategic Materials Division	a. National Materials Advisory Board
4. Defense	b. Commission on Natural Resources
a. DoD Information Analysis Centers	18. State Development Agencies
b. Laboratories (AFML, AMMRC, NRL, etc.)	
Contractor Reports (DDC)	**PRIVATE SECTOR**
5. GSA	
a. Federal Preparedness Agency	19. Universities/Academia
6. Executive	20. Industry
a. Council of Economic Advisors	a. Internal Information Systems
b. Council on International Economic Policy	b. Trade Literature
c. Office of Management and Budget	c. Manuals and Handbooks
d. CIA	d. Technical Literature
7. EPA	21. Trade Associations
a. Laboratories (Cincinnati, Las Vegas, etc.)	22. Rate Bureaus
b. Contractor Reports	23. Technical Societies
8. FEA	a. Technical Meetings
National Energy Information Center	b. Magazines, Journals
9. ERDA	c. Professional Papers
a. Laboratories (Hanford, Oak Ridge, etc.)	24. Handbooks, Textbooks, Technical Literature
b. Contractor Reports (RECON)	25. Information and Abstracting Services
10. Library of Congress	26. Independent Laboratories
a. Congressional Research Service	27. Patent System
11. NASA	28. Banking and Financial Houses
a. Laboratories (Langley, Lewis, etc.)	29. Labor Organizations
b, Contractor Reports (RECON)	30. Public Libraries
12. FPC	31. Foreign Systems and Sources
a. Office of Economics	32. Newspapers, radio, TV, etc.

throughout the materials cycle. including economic analyses and projections thereof,

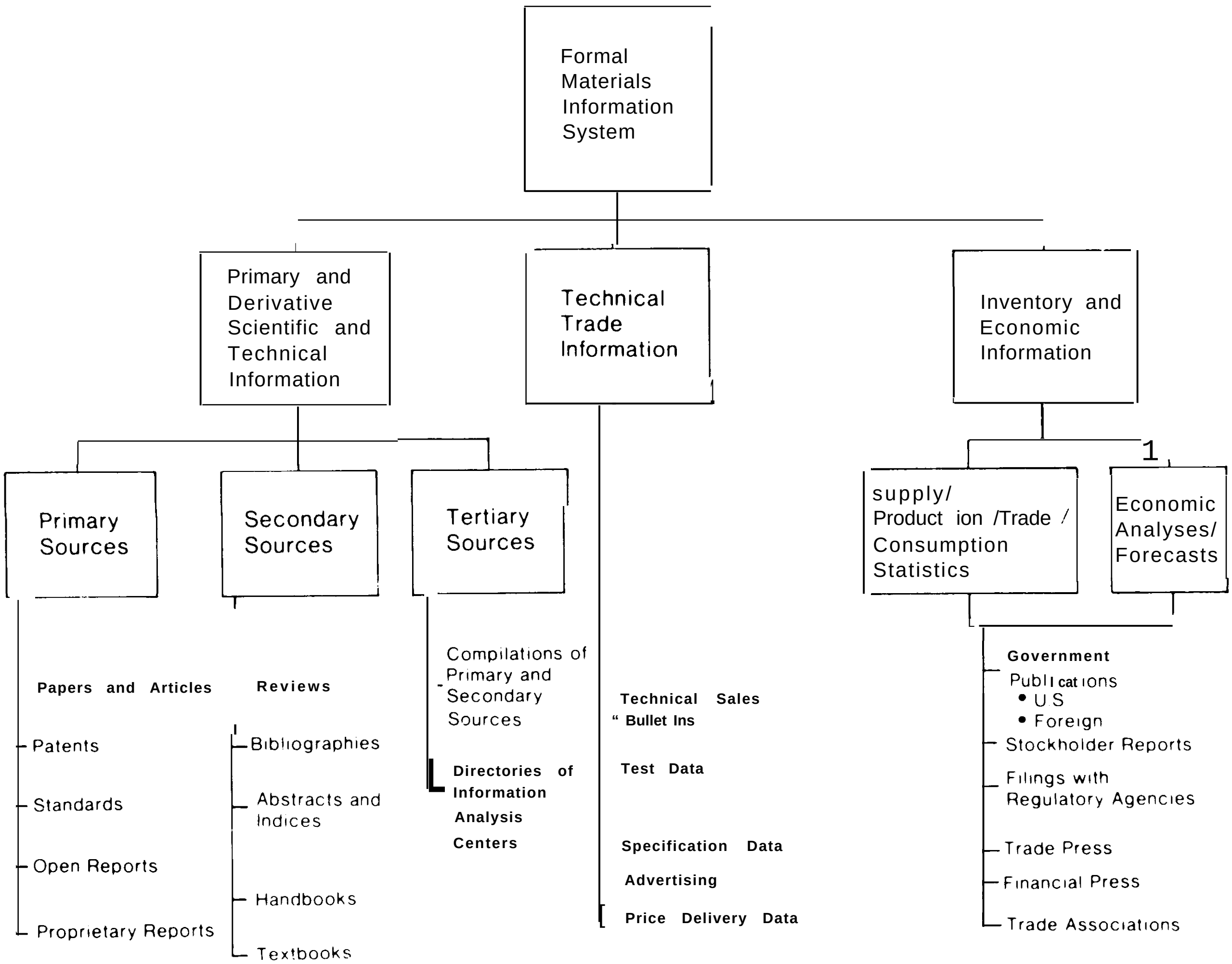
Each step in the materials cycle generates information, some more oriented toward one category than to another. In general, though, all three categories of information flow from each step. as indicated in figure II–5.

1. Scientific and Technical Information

Technical materials literature is the most common form of scientific and technical information. Its volume is large and growing, as the following instances illustrate:

- The American Society for Metals lists more than 1,000 worldwide journals that publish papers on the properties, production. fabrication, treatment, finishing. and applications of metals. About 100 of these are English language journals having metals technology as their principal thrust.
- A selective guide to sources of fibers and textile information cites 16 journals in that field.

Figure II–4. Categories of Materials Information



Note Depicted here are the information products per se, not the services which produce them

- A Federation of Materials Societies survey of the information services of 13 materials-oriented societies (excluding wood or fiber fields) showed publication in 1971 of 95.000 journal pages: in addition, the societies published 217 conference proceedings in a 3-year period (ref. 5). A selective guide to metallurgy literature alone cites 10 professional societies and 35 research and trade associations, man y of which sponsor primary publications.
- The number of scientific and technical reports published by the U.S. Government is estimated to be **80,000** per year. of which a substantial number deal with materials issues.
- Some 35 States and the Federal Government generate materials standards. The Department of Defense has issued over **35,000,** the General Services Administration another **6,000.** In addition. over **400** nongovernment technical and professional groups issue them.

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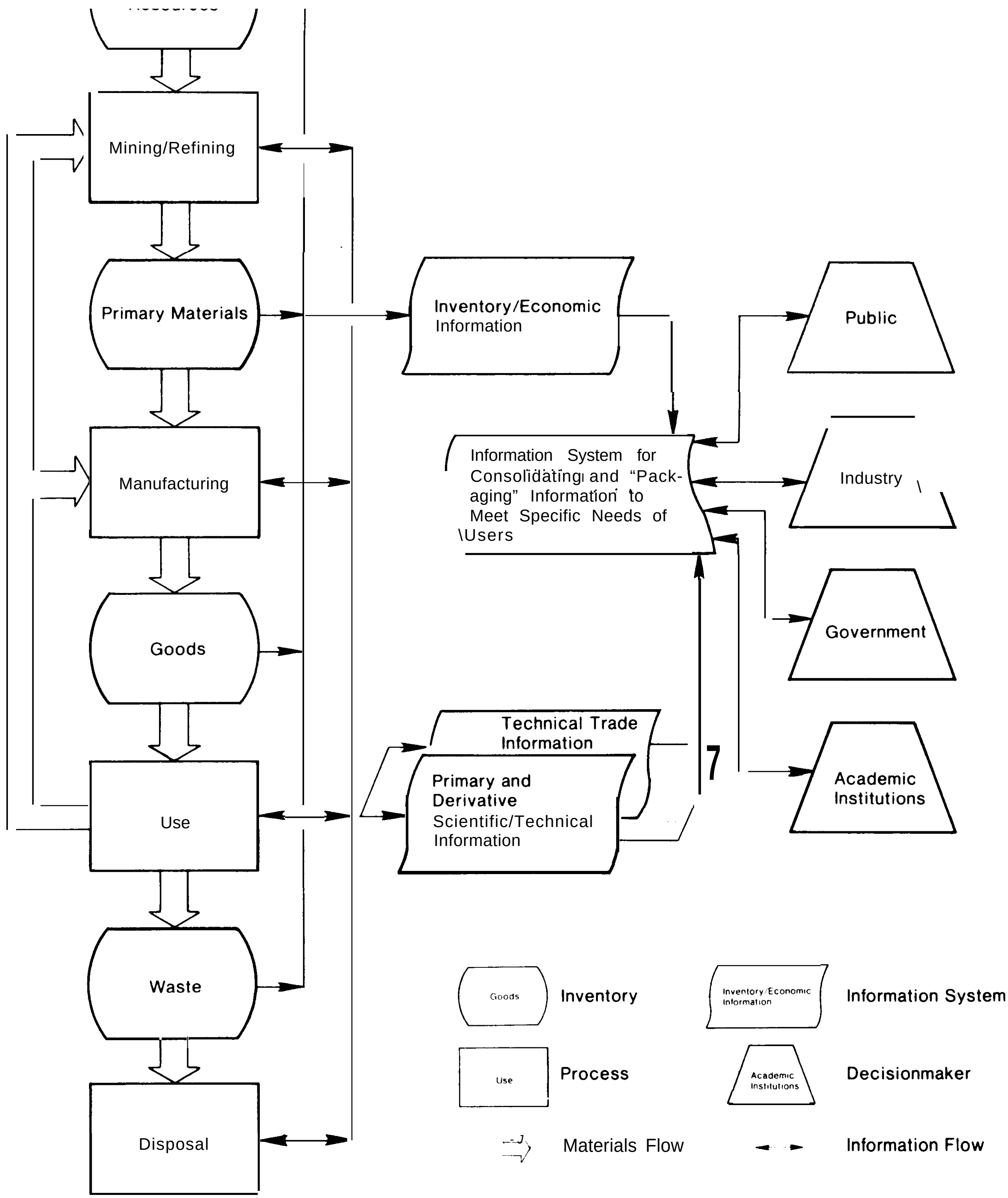
Figure II–5. Flow of Information Through the Materials Cycle



- In a report prepared for the Organization of Economic Cooperation and Development (OECD), Anderla projected the number of scientific and technical articles that would be published in 1985 to be three to four times the number in 1970 (ref. 6). Anderla also projected that:[2]

—In 1967, holdings of scientific and technical information (covering all fields and including primary, secondary. and trade data) amounted to 250 million pages and were being generated at a rate of 45–50 million pages per year.
—The world stock of articles in 1967 numbered at least 20–30 million.
—Contrary to earlier predictions, the growth of technical information would continue, at a rate between 7.2 and 13.5 percent per year (corresponding to a doubling every 5.5 to 10 years).

This explosion of primary technical publications is not a recent phenomenon. As long ago as 1830, as the number of journals proliferated, secondary sources in the form of abstracting services first came into being. Garvey and Compton estimate that they have since grown exponentially, by a factor of 10 every 50 years (ref. 2). A selective guide to sources of metallurgy information lists 58 abstract journals and an additional 25 index publications. A similar guide to fibers and textile information notes 30 abstracting services. The number of abstracts published by the materials societies polled by the Federation of Materials Societies (FMS) in 1971 (ref. 5) was in the range of 125–175,000 per year. Using Anderla's "conservative" projection rate of 7.2 percent per year, the current rate of abstracts for the 13 societies alone may be approaching a quarter-million per year. Other secondary sources are handbooks and textbooks. A guide to fiber and textile literature cites 11 handbooks and encyclopedias of general interest. A similar guide to metal literature notes 31 handbooks, still other handbooks compile information on wood. The FMS survey found that the 13 materials societies polled alone published 234 technical books over a 3-year period (ref. 5).

As the volume of primary and secondary material grow, a need arises for two new information services: tertiary compilations of secondary sources and directories of information analysis centers. (References 8 and 9. sources of many of the statistics cited here. are examples of tertiary sources.) Information analysis centers are facilities for evaluating information on particular materials; they are further described later in this chapter.

2. Technical Trade Information

This second category of materials information covers technical brochures, specifications. test data and the like distributed by firms. often through sales engineers. to promote the sale of materials. For a variety of reasons. this category has not received the same development and attention as have the more scientific systems. As a practical matter, however, it probably represents the most important source of materials information for smaller companies without science-oriented staffs.

In a study in the United Kingdom. Wolfe has shown that personnel in the textile industry and in metal industries each derive 40 percent of all the written information they use from trade literature (ref. 3). Although no comparable study has been conducted in the United States, there is reason to think the percentage may be even higher.

While some observers see "a decreasing amount of good technical literature available from materials suppliers" (ref. 10), much of it appears to be excellent. Recognizing the importance of describing their products to prospective customers, many of the larger firms operate extensive trade information services. Examples include E. 1. duPont de Nemours & Co., which has implemented a telephone system for accessing a central information base that currently handles nearly 10,000 calls per month, and Climax Molybdenum Co.

[2] It should be noted that some of Anderla's conclusions are disputed by other information investigators; see ref. 7.

3. Inventory and Economic Information

Much of the information in this third category, covering quantities and prices of materials throughout the materials cycle, is generated by industrial organizations. Much of it is compiled by trade associations and by an array of special trade and financial journals. such as The American Metal Market and Metal Week, Additional information is contained in stockholders reports and in filings with regulatory agencies. Another large segment of this kind of information. however, is proprietary and not available to the general public, Government executive departments, or Congress.

A principal source of "open" inventory and economic information includes the more than 20 Federal Government agencies that collect data elements from materials-oriented organizations and publish aggregated information. While much of the data are obtained on a voluntary basis, many of the agencies derive their collection authority from specific legislation. For example, the Bureau of the Census has conducted a census of minerals (currently on a 5-year cycle) since 1840. The International Trade (Tariff) Commission reports the annual domestic production and sales of synthetic organic chemicals and the raw materials for producing them under provisions of the Tariff Act of 1930.

The volume of Government-generated information is very large. As one indicator of its scope, the Bureau of Mines, one of the principal agencies in the minerals field, typically issues some 750 separate reports each year. One series, the Mineral Industry Survey, covers some 250 reports containing economic data on 95 commodities: some of these reports are issued weekly, others monthly. and all are issued annually. Other series cover a variety of technical and economic subjects: in fiscal year 1975 they comprised over 20,000 published pages.

Industry as well as Government analysts rely on Government-derived information. In many instances, no alternative sources exist since individual firms are often reluctant to provide comparable data to nongovernment agencies and other firms do not accept as accurate the data that is gathered.[3]) Moreover, for legal [antitrust) reasons, individual firms or associations may be, or consider themselves to be, precluded from collecting industry wide, national data,

4. Information Handling

The methods employed for collecting, sorting, consolidating, analyzing, and distributing information to users vary with the category of materials information. The most advanced in terms of use of specialized facilities and automation are the methods for handling scientific and technical information. Since the largest portion of this kind of information is in documents, the principal means for processing is the technical library. Processing functions include all the basic library services: obtaining and controlling documents, abstracting, indexing, and providing awareness of relevant new information.

Many science-oriented materials organizations have formally recognized the importance of information and formed special information groups to supplement the normal library functions. In these groups, materials specialists who develop a first-hand familiarity with the literature perform a variety of personalized, indepth services for the researcher. A 1959 survey of science-oriented chemical industries showed that 40 percent of the responding organizations spent from 1.5- to 2,5-percent of their research budget on library/information group activities; another 15 percent of the organizations spent from 2.5 to 10 percent (ref. 11). Although more recent comprehensive data are not available, there is reason to suspect that the 1.5 to 2,5 percent-range may

[3] A case in point concerns toluene. Production statistics compiled by a trade association based on voluntary submissions have been found to differ by as much as 40 percent from similar statistics published by the Government.

still be representative. A large automobile company currently spends 1.5 percent of its research budget on technical information services; the National Bureau of Standards allocates 2 percent of its budget to information services.

Over the past .20 years, the research-oriented information processing functions have been expanded through the development of several new computer services. One application is the automatic preparation of bibliographies of selected fields, a service now broadly available for purchase or lease at relatively low cost. Another application involves advances in indexing and the use of interactive searching. in which the researcher observes the output of a computer in realtime and appropriately redirects its search rout inc. Computers have also had wide use for selective dissemination of information, in which reports are distributed on the basis of a computer comparison of individuals' interest profiles with assigned index characteristics. A variety of other advanced computer functions have also been suggested (ref. 12).

One of the other new services that have developed for scientific and technical information is the information analysis center. Information analysis centers are:

> ... formally structured organizational units, specifically (but not necessarily exclusively] established for the purpose of acquiring. selecting, storing, retrieving, evaluating. analyzing. and sythesizing a body of information and/or data in a clearly defined specialized field or pertaining to a specified mission with intent of compiling. digesting. repackaging, or otherwise organizing and presenting pertinent information and/or data in a form most authoritative, timely. and useful to a society of peers and management, (ref. 13)

Forerunners of information analysis centers date back to the 19th century, but their modern development began with the rapid expansion in major research and development programs following World War 11. Some of the earliest centers were materials-oriented. Since 1958, they have proliferated, and there are now about 100 federa11y sponsored centers of which about half (58) are materials-oriented, In addition there are perhaps a half-dozen materials information analysis centers that are totally privately financed. Table II-6 lists some of the federally supported materials-oriented centers, as compiled by The National Referral Center.

Typically. the services provided by an information analysis center include both center- initiated products of general interest to all subscribers and custom-tailored services in response to user requests. Examples of the former are critical data compilations (in which an authority in the field reviews and comments on the validity of newly acquired data), bibliographies. state-of-the-art reviews, and newsletters. Custom services include selective 1iterature searches and consultation on specific problems,

The essential characteristics of the materials information analysis center that distinguishes it from a library are its focused area of interest and the unique, specialized competence of its staff, The size and scope of operations of different centers vary greatly, Some are staffed by as many as 100 or more professionals, others by as few as one or two. Descriptions of a large, medium. and relatively small center are presented in table 11-7,

In addition to information obtained from the scientific - technica1 category, information processing in support of the designer. the engineer, the purchasing agent, and others concerned with the practical applications of materials leans heavily on technical trade information. In contrast to the approaches that have evolved for servicing the research and technology community. there are few standardized approaches for handling technica1 trade information. Most corporations, even the largest, rely on procedures that are locally devised and implemented by the various engineering groups. An exception, perhaps indicative of a trend. is the Engineering Materials and Processes Information System (EMPIS) operated by the Corporate Research and Development t group of the General Electric Company (GE). In operation for 40

Table n-6.-Some Materials-Oriented Information Analysis Centers

Name	Location	Operator	Sponsor	Staff Size
Air Pollution Technical Information Center (APT ICI	Cleveland Ohio	National Aeronautics and Space Admin		13 full -time
Alloy Data Center	Washington DC	Alloy Physics Sect Ion		2 full -time 2 part-time
Atomic Energy Levels Data Center	Washington DC	NBS	NBS	1 physicist 1 chemist 1 full -time clerical asst
Atomic Transition Probabilities Data Center	Washington DC	NBS	NBS	2 part- time physicists
Bureau of Mines Associate Director Mineral and Materials Supply Demand Analysis	Washington DC	Dept of the Interior		300
Bureau of M)nes—Mineral Supply Alaska Field Operation Center	Juneau Alaska		16 full-time 9 engrs	1 geologist
Bureau of Mines --Mineral Supply Eastern Field Operation Center	Pittsburgh PA			35 full-time
Bureau of Mines—M,neral Supply Western Field Operation Center	Denver Colo			40 full-time
Chemical Kinetics Information Center	Washington DC	Physical Chemistry Division	NBS and U S Naval Ordinance Command	3 professionals 1 semi-professional 2 clerical
Chemical Propulsion Information Agency (CPIA\	Silver Spring MD	John Hopkins Univ	Defense Supply Agency Depts of the Navy Army and Air Force and Nail Aeronautics and Space Admin	1 1 professional physicists chemists and engineers and 1 1 staff members
Chemical Thermodynamics Data Center	Washington DC	NBS	NBS	7 chemists 1 technical asst 2 clerks
Controlled Fusion Alomic Data Center	Oak Ridge TN	Oak Ridge Natl Lab	ERDA	4 Scientists 2 non technicals (full- time)
Criticality Data Center	Oak Ridge TN	Union Carbide Corp	ERDA	1 professional and 1 2 nonprofessional
Cryogenic Data Center	Boulder Colo	NBS	NBS NASA American Gas Assoc	Full- time 4 physicists 1 chemist 2 engrs 1 documentation spvr 3 clerks part-time 1 physicist 1 engr 3 clerks
Crystal Data Center	Washington DC	NBS	NBS	Full-time 3 crystallo graphers 1 technical asst
Data Center for Atomic and Molecular Ionization Processes	Washington DC	NBS	NBS	? professionals and full-time clerical support
Data Center on Atomic Line Shapes and Shifts	Washington DC	NBS	NBS	1 part-time physicist
Diatomic Molecule Spectra and Energy Levels Center	Washington DC	NBS	NBS	1 physicist
Diffusion in Metals Data Center	Washington DC	NBS	NBS	2 full-time and 4 part-time
DOD Nuclear Information and Analysis Center (DASIAC)	Santa Barbara CA	GE TEMPO	DNA	24 full-time
Earth Resources Observation System (EROS) Data Center	Sioux Falls SD	U S Geological Survey		210 full-time
Ecological Sciences Information Center	Oak Ridge TN	Oak Ridge Natl Lab	AEC	1 manager 3 Information Specialists-biologists (1 half-time) 2 information technician assistants
Electrolyte Data Center	Washington DC	NBS	NBS	2 part-time
Electronic Properties Information Center (FPIC)	West Lafayette IND	Purdue University	DSA	4 full-time 4 part-time
Energy Information Center	Oak Ridge TN	Oak Ridge Natl Lab	Nail Science Foundation RANN Program	3 full-time
Environmental Information Analysis Center (EIAC)	Columbus ohio	Battelle Mem Inst	ERDA	3 full- time
Environmental Information Division	Maxwell AF Base ALA	Alr Training Command		4 full -time
Environmental Mustagen Information Center	Oak Ridge TN	Oak Ridge Nail Lab	ERDA Natl Inst of Environmental Health Sciences	2 full-time 1 part-time
Eutrophication Information Program	Madison WIS	University of Wisconsin	Dept of the Inter Dept of Agric U S Environ Protect Ion Agency Univ of Wisconsin	1 full time 5 part-time

Table n-6.-Some Materials-Oriented Information Analysis Centers (Continued)

Name	Location	operator	Sponsor	Staff Size
Gamma-ray Spectrum Catalogue	Idaho Falls Idaho	Nail Reactor Testing Station	ERDA	12 part-time
Health and Safety Analysis Center	Denver Colo	DOI		66 engineers statisticians mathematicians and clerks
High Pressure Data Center	Provo Utah	Brigham Young Univ	NBS	2 full-time 1 part-time
Infrared Information and Analysis Center (IRIA)	Ann Arbor Mich	Environmental Res Inst of Michigan	Det Supply Agency Office of Naval Research	4 full-time 412 clerical 30 to 40 technical staff members
LMFBR Fuel -Cladding In forma tion	Richland Wash	Hanford Engr Dev Lab	ERDA	5 full time 1 part -time
Machinability Data Center	Cincinnati Ohio	Metcutl Research Assoc Inc	Army Materials and Mechanics Research Center Watertown Mass	8 lull-time 5 part tilme
Mechanical Pro Dept, es Data Center	Traverse City Mich	Belfour Stulen Inc	AMMRC Watertown Mass	13 full time
Metals and Ceramics Information Center (MCIC)	Columbus Ohio	Battelle Memorial Institule	AMMRC Watertown Mass	100 paft time 21 full time
Microwave Spectral Data Center	Washington DC	NBS	NBS	1 sclentist
Molten Salts Data Center	Troy NY	Rensselaer Polytechnic Inst	NBS	Director and postdoctorate and predoctorate co workers with specialties in fused Sal S physical properties and electroochemistry ,
National Oceanographic Data Center	Rockville MD	NOAA		76 professionals and 43 nonprofessionals
National Space Science Data Center	Greenbelt MD	GSFC	NASA	92 full [(me
Nondestructlve Testing Informafion Analysis Center	Watertown Mass	AMMRC	AMMR	4 part time 3 technical professional and 1 clerk
Nuclear Data Project	Oak Ridqe Tenn	Oak Ridge National Lab	FRDA	1 1 professionals and 8 nonprofessionals
Nuclear Safety Inform a! or Center	Oak Ridge Tenn	Oak Ridqe National Lab	ERDA	12 part time
Phase Diagram Y for Ceramists	Washington, D C	NBS	NBS American Ceramic Society, Inc	3 part time
Photonuclear Data Center	Washington D C	NBS	NBS	3 nucl, ar physicists 1 clerk
Physical Data Group	Livermore Calif	University of call fornia		1) fu l time
Plastics Technical Eva 111a tion Center (P: ASTEC)	Dover N J		Army Materia Con	1 7 fu time
Radiation Chemistry Data Center	Notre Dame Ind	Radiation : ab	NBS ERDA	4 full time 2 pa, t tme
Radiation Shielding I. formation Center	Oak Ridge Tenn	Oak Ridge Nat, onal Lab	F RDA De fense Nuc ear Agency	1 2 fu , t me 4 p., rt t n e 5 member technic a advsor, c ommittee
Rare Earth Informati on Center (RIC)	Ames Iowa	Io wa State University	ERDA	1 5 fu l time 1 part time 1 half l ime
Reliability Analysis Center	Griffiss Air F err,. Base N Y	RA DC (RBR AC)	Grifiss Air Force Base Andrews 4(I F orce Base	1 5 fulltime
Rock Properties Information Center (RPIC)	West Lafayette Ind	Purdue Uni, ersit,	Nat, ona Science F oundation (RANN) Purdue s Thermo physical Properties Research Center	6 part time
Shock and V! bration Information Center	Washington O C	Naval Research . ah	Dept of De fense & Natl Aeronautics 8 Space Admin	F ful time
Superconductive Ma terials Data	Schenectady N Y	General Electric Research & De v C tr	NBS	? part t me
able of Isotopes Project	Berkeley Calf	Univ of Call forni d	NBS ERDA	1 seni or ompie r 4 fu time ? p art time t typist 1 r omputer programmer
hermophysical Properties Research Center (TPRC)	West Lafayette Ind	Purdue Univ	U S Government Agencies	Approximately 37
oxic Materials Informati on Center (TMIC)	Oak Ridge Te nn	Oak Ridge N . ab	Natl Sc ence F r undat I on AEC	5 professiona s
JSAF Environmental Tech Applications Center	W ashington D C	Nav y Yard Anne x	U S Air Force	200
(flay Attenuation Coefficient nformation Center	Washington D C	NBS	NBS Defense Nuc lear Agency Dept of Defens I=	1 fu l time 1 1 4 time

Source National Referral Center *Directory o f Federally Supported Informa tion Analysis Centers* Washington D C Library ot Congress 1974

Table n-7.-Large, Medium, and Small Specialized Materials Information Analysis Centers

METALS AND CERAMICS INFORMATION CENTER (MCIC) Battelle Memorial Instltute Columbus Laboratories Columbus Ohio 43201 SPONSOR Department of Defense Off Ice of the Director of Defense Research and Englneerlng under a Defense Supply Agency contract monitored by the Army Materials and Mechanics Research Center, Watertown, Mass YEAR STARTED 1955 STAFF 100 part-time professional technicals (20 percent), 7 full-time professional technicals, 4 full-time information specialists and 10 full-time typing and clerical MISSION To provide technical assistance and information on materials within the Center s scope, with emphasis on application to the defense community SCOPE Metals Titanium, aluminum and magnesium beryllium refractory metals high-strength steels, superalloy (primarily nickel- and cobalt-base alloys) and rhenium and vanadium *Ceramics* Borides, carbides, carbon/'graphite nitrides oxides, sulfides silicides intermetallics, and selected glasses and glass-ceramics Composites of these materials, coatings, environmental effects mechanical and properties materials applications, test methods sources suppliers, and specifications other materials mutually agreed upon by the contractor and the Government HOLDINGS Reports on Government-sponsored research journals patents data, trade literature books PUBLICATIONS Monthly newsletter (disseminated free by the Center to anyone engaged in materials research development, or utilizatlon), a series of weekly reviews on developments in metals technology, a monthly review of ceramic technology, a variety of engineering reports and handbooks related to the utilizatlon of advanced metals and ceramics The reviews, reports and handbooks are available at cost from the National Technical Information Service SERVICES Answers to technical inquiries, bibliographies, literature, searches and special studies are provided on a fee basis depending on the time involved QUALIFIED USERS Services are available to the technical community without restrictions	**MACHINABILITY DATA CENTER** Metcut Research Associates Inc Clnclnnati Ohio 45209 SPONSOR The center is operated by Metcut Research Associates Inc under contract to the Defense Supply Agency with technical aspects being monitored by the Army Materials and Mechanics Research Center Watertown, Mass YEAR STARTED 1964 STAFF 7 machining data analysts (3 full-time and 4 part-time), 3 systems and data processing personnel (2 full-time and 1 part-time), 1 document acquisitioner (full-time), 1 user/inquiry controller (full-time), and 1 management (full-time) MISSION To collect evaluate, store and disseminate material removal information including specific and detailed machining data for all types of materials and material removal operations both conventional and unconventional SCOPE All kinds of material removal operations such as turning milling drilling grinding, electrical discharge machining electrochemical machining chemical machining, etc with strong emphasis on engineering evaluation for the purpose of developing optimized material removal parameters such as speeds feeds depths of cut tool material and geometry cutting fluids and other significant variables HOLDINGS Over 32000 evaluated documents that can be retrieved specifically by content using a computerized system PUBLICATIONS *MDC Machining Briefs* (distributed free to MDC Users) *NCECO-N/C Maching Costs* (computer program 1 973) *Machining Data Handbook* (2d ed 1972), *Machining 01 High Strength Steels with Emphasis on Surface Integrity* (1970), *Determination and Analysis of Machining Costs and ProductIon* Rates Using Computer *Techniques* (1968), *Machining Data for Nurnerical Control* (1 968) and 1968 *Supplement to Machining Data for Numerical Control Grinding Ratios for Aerospace A//oys* (1966) *Machining Data for Beryllium Metal* (1966), *Machining Data for Titanium A//oys* (1 965) SERVICES Answers inqulrles, provides consulting, reference literature-searchlng abstracting and Indexing, and reproduction services, provides R&D information conducts seminars, lends materials, makes referrals to other sources of Information, permits onsite use of collection Answers to inquiries that can be handled quickly over the phone are provided free, other services are provided on a fee basis QUALIFIED USERS Anyone, with certain limitations in foreign disseminatlon	**RARE-EARTH INFORMATION CENTER (RIC)** En erg y and Mineral Resourc es Research Institute Iowa State University Ames Iowa 50010 SPONSORS The Ames Laboratory of the U S Atomic Energy Commission and over 40 U S and foreign rare earth producers and advanced technology corporations YEAR STARTED 1966 STAFF 1 5 full-time professional (chemistry) and 1 part-time professional (metallurgy) 1 half-time nonprofessional MISSION To serve the scientific community by collecting storing evaluating and disseminattng rare earth information from various sources SCOPE The Center is concerned primarily with the physical metallurgy and solid state physics of the rare metals and their alloys but it also maintains files on the analytical Inorganic and physical chemistry geochemistry ceramics and toxicity of the rare earth elements and compounds HOLDINGS About 5 000 reprints reports and books PUBLICATIONS *Rare Earth Information Center News* (quarterly distributed free) technical reports state-of-the-art reviews data compilations bibliographies SERVICES Answers inquiries, provides literature-searching and abstracting and Indexing services, prepares in-depth reports, makes referrals to other sources of Information, permits onslte use of collection A minimum charge of $25 has been set to cover the expenses involved in answering most typical inquiries QUALIFIED USERS Anyone

Source National Referral Center *Directory of Federally Supported Information Analysis Centers* Washington D C Library 01 Congress 1974 years, EMPIS provides a systematized materials description service for GE operating departments. System output is principally in the form of coded pages of text, tabulations, and diagrams. Currently EMPIS contains over 21.000 pages: about 3,000 are added or updated each year.

Some of the technical library services described previously are also used to support engineering information needs. So too are the materials information analysis centers; many offer focused consul tat ion on particular problems.

For support to management and related planning functions, inventory and economic information is of principal interest; of course. information from the other categories is involved as well. Even less than procedures for handling technical trade i n format ion, standardized processing procedures for the management and planning functions are undeveloped. To be sure. materials industries have always recognized the need to be able to project the demand for their products. This is an essential element in planning plant capacity and related production inputs, and a variety of planning tools have been developed for the purpose, each unique to a particular business. But the emphasis was uniformly on projected demand. Although some significant materials shortages occurred in the 1950's, it was not until 1973–74, when supplies suddenly became exceedingly short, that the need surfaced to consider seriously the supply side of the equation as well, In the face of the more complex materials problems now emerging, more sophisticated planning tools have had to be developed which take a variety of supply factors into account. Thus, a company which converts raw materials to an intermediate material needs to consider not only the effects of interruptions in raw material supply but also shifts in demand brought about by a shortage in a substitute raw material as well as the uncertain intent ions of competitor producers.

The analytical techniques for accomplishing such industrial analysis are still in the very early stages of development, The problems are very difficult and beyond the capability of most companies. Only a very few large organizations have formed special materials strategy groups to deal with them. While the analytical methods vary from one industry to another, several common concepts are evident:

- The strategy analysis draws on information from every aspect of the business: resource and development, engineering. purchasing. finance, and marketing. It demands a level of comprehensive skill that is usually in very short supply and is probably beyond the capability of smaller companies to develop for themselves. Specialized consulting companies are beginning to offer this capability.
- There is heavy reliance on information that is available only from Government sources.
- Computers play only a minor role in the analysis. At this stage of industria1 supply/demand model development, there are few realtime constraints ca11ing for computers. The principal challenge is for analysts to derive proper analytica1 relationships. In the future. planning systems conceivably might weigh the effects of very short interval changes in supply and demand estimates and in other exogenous variables and report them to policy makers in near real-time. but it is not clear when, or if, this will ever be necessary.

While industrial organizations are concerned with analysis of their own supply/demand variables, Government agencies are concerned with aggregated analysis. both of selected industrial segments and of the economy as a whole. A large number of agencies are involved in developing these analysis procedures, A recent review of Government activities to avert and alleviate materials shortages showed that some 57 executive agencies, 15 congressional committees, and 3 congressional offices are involved in policy planning (ref. 14), Just as inventory and economic information is collected by agencies on an autonomous basis, so too the Government's systems for processing inventory and economics information have largely been uncoordinated. As an outcome of the materials shortages of 1972–73, efforts are now underway to improve this situation, especially to effect closer coordination within individual departments {such as among the different groups in the Department of the Interior). Nevertheless, the state of development of combined supply/demand analytical models is still relatively immature, Until the late 1960's, few Government agencies were using sophisticated analytical techniques. Probably the most advanced were those in the Department of Agriculture for renewable materials, which were patterned along those used for food commodities. With regard to mineral commodities, the responsibility for tying supply and demand together has not been clearly established.

E. SUMMARY

The review of existing materials information systems confirms several impressions and indicates several trends. Although largely uncoordinated. individual systems in industry, academic institutions, and Government have all played important contributing roles in the development of U.S. materials policy, In the past, and continuing even today, the most formally developed information systems deal principally with scientific and technical information. Least developed are the systems dealing with economic and inventory information, and particularly lacking are the analytical information processing techniques for interpreting data. In the face of the growing need that policy makers have for materials information, these deficiencies become even more significant.

Whether or not, in light of emerging issues and considerations, these systems adequately meet the particular needs of Federal policy makers is examined further in chapter III.

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Chapter III

THE NEED FOR IMPROVING FEDERAL MATERIALS INFORMATION SYSTEMS CAPABILITIES

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THE NEED FOR IMPROVING FEDERAL MATERIALS INFORMATION SYSTEMS CAPABILITIES

The existing Federal materials information systems, designed for different purposes, are loosely connected and do not provide Government policy makers with adequate information to deal with current materials issues. In particular, they cannot be used to forecast possible shortages, judge their impacts and the market's ability to absorb them, or test the effectiveness of alternative policy responses.

The functional requirements needed to improve existing materials information systems capabilities were developed through a review of the literature and a series of interviews with a cross-section of policy makers. H was found that more comprehensive and integrated systems capabilities were needed to deal with current materials problems. It was also noted that these capabilities should include techniques for interrelating data regarding the principal supply and demand factors so as to illuminate their effects on materials flow.

A. INTRODUCTION

In responding to materials problems. (government policy makers rely on information obtained from industry, academic institutions. State and local governments, as well as from Federal agencies For years the loosely coupled system that assembled. organized. analyzed, and distributed this information worked reasonably well. On the whole, the problems policymakers confronted were limited in scope, and timeliness generally was not a critical factor. Thus for example, the ability of specialist at the National Aeronautics and Space Administration (NASA) to obtain information needed to carry out space programs. such as the state of development of new advanced composites to replace titanium and other metals, was generally satisfsctory, Similarly, international trade analysts at the Departments of State and Commerce could rely almost entirely on import and export statistics assembled by the Bureau of the Census and the International Trade Commission.

Serious shortcomings in the ability of these materials information systems to deal with shortage induced crises were first spotlighted in 1973 and 1974. Then, faced with the need to determine quickly whether the effects of the wheat shortage and the oil embargo could be contained by the market or whether Government interaction would be required, policy makers found that their information systems were deficient, This portion of the assessment examined whether or not that condition was symptomatic of general shortcomings in the Government's materials information capability and, if so, whether and how it might be corrected.

The assessment consisted of a series of step-by-step analyses in which hypotheses were advanced, tested, and successively reshaped. The initial steps in this approach proceeded as follows:

- The literature on materials information was critically reviewed.
- Based on information gathered from the literature, a tentative thesis was advanced that a significantly improved system was needed, and a set of provisional functional requirements for it was tentatively postulated.
- These premises were checked against the perceived needs of experts, as expressed in earlier studies and pending congressional actions on materials information systems.
- The premises were further tested and sharpened through a series of interviews with materials policymakers and specialists,
- In addition, views of several foreign experts with relevant experience were obtained.

The results of these steps, described in this chapter, supported the hypothesis that improved capabilities were needed and provided the basis for subsequent analysis of how they might be implemented.

B. LITERATURE REVIEW

Over the past 25 years there have been at least four major studies of national materials policy, The first was by the President's Materials Policy Commission in 1951, The second was begun in 1970 with the establishment by Congress of the National Commission on Materials Policy. In that same year the National Academy of Sciences appointed the Committee on the Survey of Materials and Engineering (COSMAT) to conduct a comprehensive survey of materials science and engineering. Most recently, in 1974, Congress established the National Commission on Supplies and Shortages. The reports of the three completed studies refer to and, in varying degrees. make suggestions regarding the role of information in formulating and executing materials policy, These ideas were utilized in this assessment.

In addition, the assessment drew on several other studies which specifically focused on information aspects of materials. These included two surveys by the National Materials Advisory Board of the National Academy of Sciences (1959 and 1964), the U.S. General Accounting Office's review of the Government's machinery for dealing with commodity shortages (1974), and a survey of materials information systems conducted by the Federation of Materials Societies (1974). The findings of these earlier efforts that bear on materials information aspects are briefly summarized below:[1]

1. The President's Materials Policy Commission Report

The Paley Commission was established in 1951 in the aftermath of the major materials

[1] In addition to the cited reports. several others (ref. 1,2,3) are relevant for their development of a general economic theory of information. The absence to date of a theory for evaluating the role of information in shaping market forces may well have impealed the development of materials information systems.

disruptions and price rises of the Korean War. Not unlike the effects of the shortages of 1973-74, the Korean experience focused public attention for the first time on materials issues. The Commission examined all major aspects of the problem of insuring an adequate supply of production materials for meeting national long-range needs. In its 1952 report, Resources for Freedom: A Report by the President's Materials Policy (commission, the Commission noted the need to improve the Government's "machinery" for anticipating changes in the materials situation. Emphasizing the interrelated nature of materials issues, it held that:

> The task of broadening and improving Government analysis of materials problems would take many forms. Butt improving the various parts o f Goverment equipment dealing with the materials problem will not make the whole operation run as it should. For all its wide diversities the materials problem is indivisible. There must be somewhere, a mechanism for looking at the problem as a whole. for keeping track of changing stations and the interrelations of poicies and programs. This task must be performed by a Federal agency near the top of the administrative structure(ref. 4).

Among its many findings and recommendations, the Report recommended that the Department of the Interior strengthen its programs for gathering and analyzing minerals data. It cited several functions that an improved analysis capability required, among them up-to-date information on resources and reserves, stockpiles, and producer inventories. As a basis for its own work, the Commission developed a methodology for making long-range projections and applied it to predict (in 1952) the 1975 U.S. demand. It thereby provided an important stimulus to more deliberative, analytical use of data in formulating materials policy. [2]

2. The National Commission on Materials Policy Report

With emphasis primarily on minerals, the 1973 report of the National Commission on Materials Policy, Materials Needs and the Environment, 7'oday and Tomorrow (ref. 6), noted that "almost every aspect of policy work on this area is handicapped by inadequate, inaccurate, or inaccessible information. It recommended that improvements be instituted with regard to data collection, data handling. analysis, and reporting. The following paraphrased excerpts indicate the thrust of the findings:

- Data Collection. An adequate, accurate, and accessible data base is needed for materials, energy, and environmental policy development; available basic data is generally inadequate. There is a need for more complete and reliable data and for continuing data acquisition. Information on mineral reserves and resources is patchy, inaccurate, or obsolete; to be useful, the data must be accurate, timely. and complete before processing.
- Data Handling. Data banks now used in processing reports on mineral resources are limited in number and highly specialized in application: none permit a comprehensive evaluation of materials flow, An improved system must provide for testing the accuracy of the data and its adequacy for policy decisions. The system requires a staff to search for available data and issue periodic reports on significant materials developments. There needs to be user access to nonconfidential information from any file, A

[2] A critique of the Paley projections, comparing them with *actual* 1972 usage, was made by Cooper (ref. 5). He found that the Commission underestimated growth in population (by about 10 percent). and GNP (by about 23 percent). Notwithstanding, they *overestimated* the consumption of materials for 17 of 24 minerals examined. Cooper notes, among several other possible reasons for the errors, that the Commission erroneously assumed that relative prices of materials would remain constant. The projected scarcities may in fact have developed and forced prices to rise. thereby inhibiting demand. Cooper shows evidence of this effect. He also notes that the Commission grossly underestimated the level of investment that would be made in plant and equipment (by 100 percent). The higher than anticipated investments in technology may have increased the effectiveness with which materials were used and thus reduced demand.

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basic task would be to establish standard terms and parameters, methods of collecting data based on those standards, and systems for organizing or filing the data. The data should be in computerized storage to facilitate their utilization.

- Analysis. Techniques for supply and demand forecasting must be improved; essential to analysis are sound historical records.
- Reporting. Interpretations of analyses and evaluations should be "packaged" in such form as to assist all users of the system; they should be released periodically and on special demand.

The Commission concluded that it was feasible and desirable for the Federal Government to establish a national inventory and information center on minerals (including fuels). They saw the new information system servicing many activities, including problem solving, program development, decisionmaking, and policy formulation. To be organized under the Department of the Interior (pending establishment of a new Department of Natural Resources), it would make extensive use of computer technology and would draw on existing, unused computer capacity wherever possible.

3. The COSMAT Report

The National Academy of Sciences Committee on the Survey of Materials Science and Engineering (COSMAT) published its findings in summary form in 1974 under the title, Materials and Man Needs (ref. 7). In 1975, it issued a multivolume supplementary report detailing background information. Whereas the National Commission on Materials Policy tended to view materials as commodities with emphasis on their role in commerce, COSMAT emphasized the technological aspects of materials; it attempted to show how science and engineering could be marshaled to address materials problems. Their principal findings covered opportunities for materials research and development, Governmental and industrial roles in materials research, and recommendations for strengthening the base of technical manpower through improvement in materials education. While information systems, per se, were not considered in any detail, COSMAT did note the need of the multidisciplinary materials field for improvements in materials data and statistics gathering.

4. The National Materials Advisory Board Surveys

The National Materials Advisory Board (NMAB), a division of the National Academy of Sciences National Research Council, was probably the first group to examine materials information in detail. In 1959, at the request of the Department of Defense, the Board sought the opinions of users of materials information systems on their effectiveness, specifically to illuminate these issues:

- The seriousness of the problem of dissemination of materials information;
- The deficiencies existing in the present (1959) arrangement:
- Whether certain substantive areas had greater deficiencies than others; and
- What changes would best correct any existing deficiencies,

A questionnaire was sent to 3.500 people, and replies were received from approximately 2,000. The results provided an important early insight to user needs and preferences (ref. 8).

From the 57-percent return (compared with 20 to 30 percent normally encountered in mail surveys), the Board concluded that respondents considered the subject of materials information systems to be very important; in fact. more than 60 percent of the respondents provided expanded, narrative opinions. Reflecting a population that was decidedly scientifically oriented, respondents considered dissemination of information on applied research to be of greatest importance, followed, in turn, by basic research. development, and application engineering. With regard to which areas were encountering deficiencies, basic research and applied research and development were cited most often.

Users indicated a need for improvements in all types of basic information services. in particular abstracts, interpretive summaries, annual reviews, document distribution. bibliographic lists, information collection, technical answering services, and accession lists. Administrators stressed the need for current information: engineers wanted individual service from a technical answering facility. While all areas of materials science and technology were considered as having information handling deficiencies, those concerned with high-temperature and high-strength materials, lightweight materials. plastics, and ceramics appeared to have greater shortcomings than others.

With regard to how information systems might be improved, more than 85 percent of the respondents favored the general idea of materials information analysis centers. About 60 percent of the respondents felt that evaluation of information for scientific soundness was a necessary function. On the role of Government in fostering improvements, 94 percent of the respondents considered such a role to be suitable (about 95 percent were then using existing Government systems): however. having the information services available from nonprofit institutions was considered even more suitable. Respondents were asked to specify which Government and nongovernment bodies should serve in a continuing advisory capacity (quite apart from administrative control) with respect to materials information: 1,359 respondents cited Government agencies. with the Department of Defense and the National Academy of Sciences leading the list: some 581 respondents listed nongovernment bodies.

As to which Government agency should take the lead in managing and upgrading the information system. should such a decision be made, about 40 percent of the respondents preferred the Department of Defense. An equal number preferred a civilian agency, the Department of Commerce being the first choice. Some 20 percent preferred nongovernment control, the National Academy of Sciences being the first choice. Only 4 percent saw industry assuming this role.

In the years following the NMAB study, the Department of Defense expanded its support of materials information analysis centers, In 1964, the NMAB undertook a follow-up survey, this time focusing on user's perceptions of 10 DOD-supported centers. To obtain a more complete response than could be obtained from a mailed questionnaire some 350 people from 43 organizations were personally interviewed.[3] Table III- 1 shows the centers covered and the distribution of persons interviewed. The findings (ref. 10) provided a detailed breakdown of who was using the centers and for what, Representative of these findings, figure III-1 illustrates how users rated information centers relative to other means of acquiring information. Figure III-2 shows the relative use of the centers by category of user. Interestingly. some 80 percent of industry, Government, and research institute people used the centers, but less than 50 percent of university people.

The overall finding of the review was that materials information analysis centers were filling an important need and should be encouraged, In the following years they did grow. with strong support from the Department of Defense, the National Bureau of Standards, and other agencies. In 1972, however. a major change occurred: the Department of Defense initiated a policy

[3] A principal shortcoming of surveys in this area—experienced in the NMAB surveys and others. including those conducted as part of this assessment—is the difficulty of obtaining uniform interpretation of questions, The problem is exacerbated because "most scientists and engineers use information services only sporadically: their awareness of what they could be using is very incomplete. and more seriously. they do not reflect on their own pattern of activities sufficiently to be able to describe it" (ref. 9).

Table III-1_National Materials Advisory Board Study of Information Analysis Centers

DOD Materials Information Centers and Collections

Mechanical Properties Data Center (MP) (Belfour Engineering Company, Suttons Bay, Michigan)
Binary Constitution Information Service (BINARY) (Illinois Institute of Technology Research Institute, Chicago, Illinois)
The Groth Institute (Groth) Florida Atlantic University, Boca Raton, Florida)
Thrmophysical Properties Research Center (TPRC) (Purdue University, West Lafayette, Indiana)
Electrical and Electronic Properties Information Center (EPIC) (Hughes Aircraft, Culver City, California)
Radiation Effects information Center (REIC) (Battelle Memorial Institute, Columbus, Ohio)
Ceramics and Graphite Information Center (C&G) (Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio)
Centralizing Activity for Shock, Vibration and Associated Environments (SHOCK) (Naval Research Laboratory, Washington, D.C.)
Defense Metals Information Center (DMIC) (Battelle Memorial Institute, Columbus, Ohio)
Plastics Technical Evaluation Center (PLASTEC) (Picatinny Arsenal, Dover, New Jersey)

Distribution of Persons Interviewed

Organization		Nature of Work		Materials Interest	
Industry	197	Basic Research	64	Metals	70
University	46	Applied Research	149	Ceramics	11
Government	87	Design Engineering	31	Composites	15
Research Institute	23	Administration	13	Organics	41
Total	353	Information Activity	72	Research Materials (High purity)	23
Nature of Responsibility		Other (Service activities, e.g., testing and analysis, pilot plant)	24	Materials (Across-the board or combinations of materials)	185
Administrator	24	Total	353	Total	353
Supervisor					
Specialist	181				
Total	353				

Source: National Materials Advisory Board, Dissemination of Information on Materials.

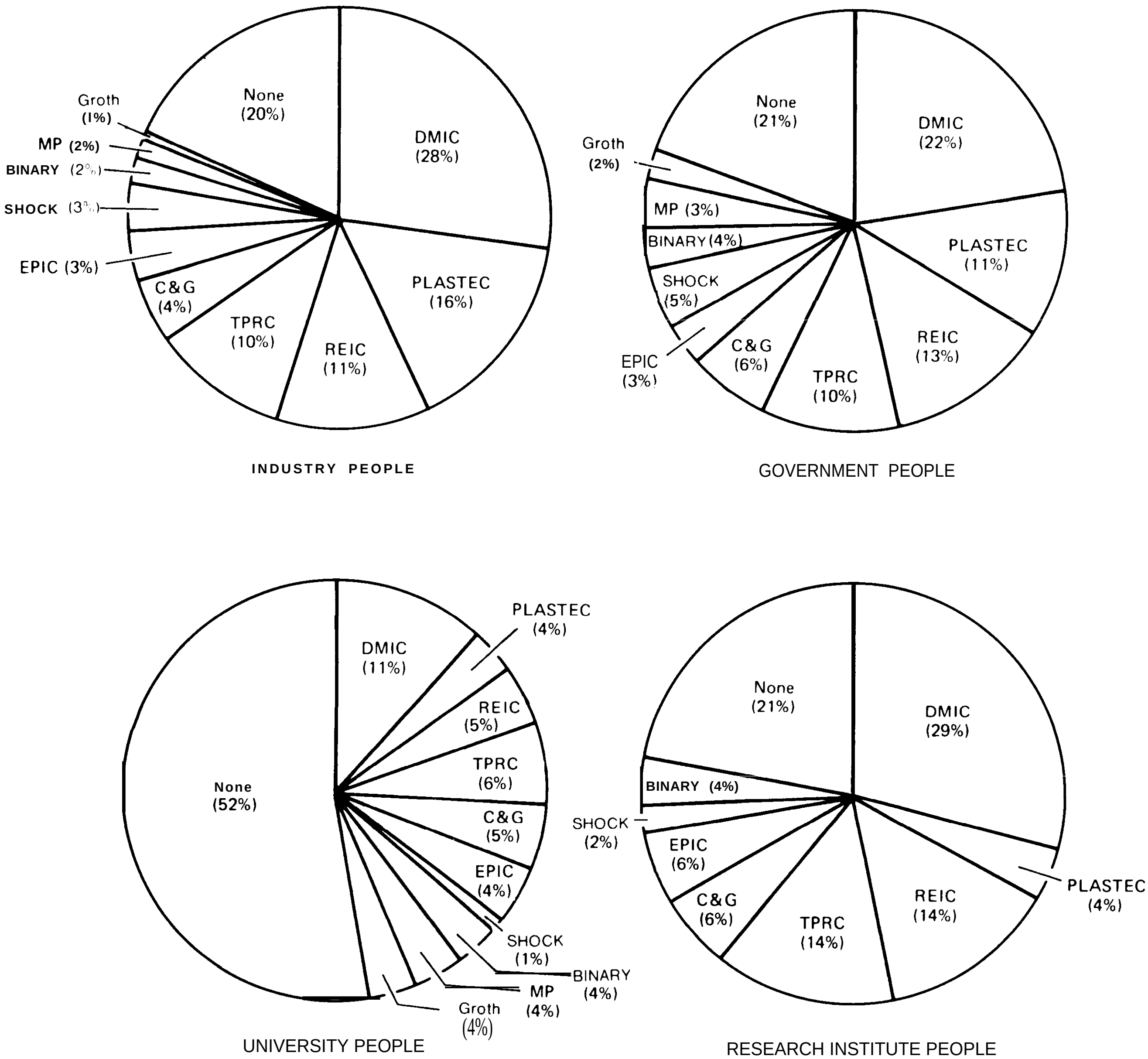
under which centers would charge users for services, Previously, the service was free to qualified Government and contractor personnel. Centers that could not become self-supporting would be closed. Indicative of the general problem of developing information services when the value of information is not clearly recognized—a condition that still exists—the views of the Department's spokesman are of interest:

> We repeatedly claim that technical information is a very valuable resource and that our technical information activities produce great benefits—yet to varying degrees we have failed to convince the people who control our resources that this is indeed true. Their quite logical response is—"OK. if it's so great, then the users certainly should be willing to foot the bill. " Frequently our response is—"Ah yes. but unfortunately the user and the people who control his resources do not realize how valuable our services are-and besides, they are not accustomed to paying for information services. " To me. the message is clear-if wc are to maintain viable information activities. we must do a better job of establishing the benefits of these activities. Se:rvice charges are one mechanism of establishing benefits which is clearly understandable to the people who have to make resource decisions for technical information activities (ref. 11),

5. GAO REPORT ON COMMODITY SHORTAGES

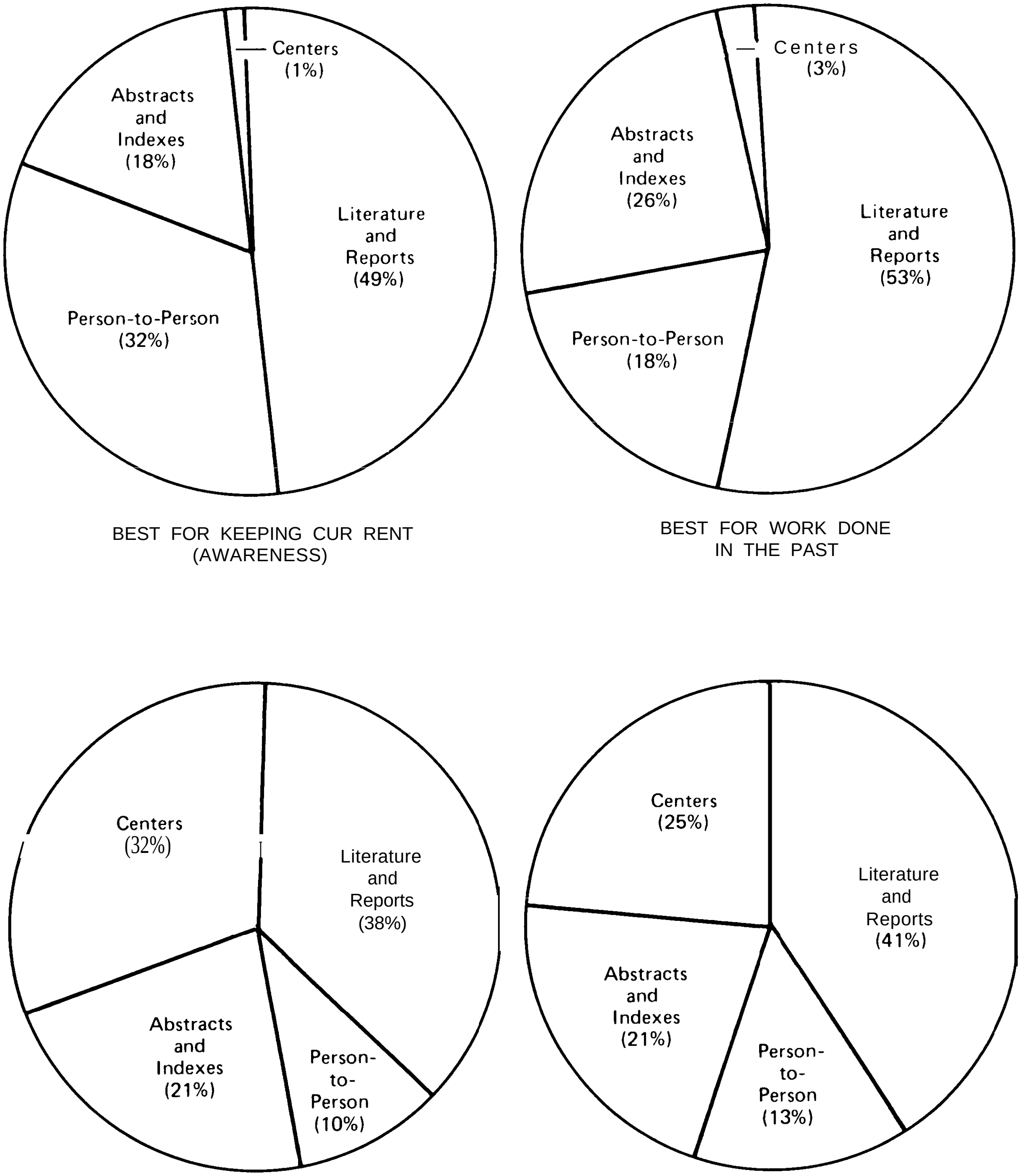
The General Accounting Office's (GAO) review, U.S. Actions Needed To Cope With Commodity Shortages (ref. 12), covered the performance of the Government's materials information system during the 1973–74 materials crises, The study found that the executive department agencies responsible for commodities . monitoring and forecasting lacked sufficient organizational or analytical

Figure Ill-1. DOD Materials Information Centers-Relative Use by Type of Organization.



Source: National Materials Advisory Board, *Dissemination of /formation on Materials*.
Note: See table III-1 for the names of centers.

Figure III-2. Tools or Techniques for Acquiring Information for Various Types of Needs



BEST FOR KEEPING CUR RENT (AWARENESS)

BEST FOR WORK DONE IN THE PAST

FOR RECENTLY NEEDED INFORMATION (IMMEDIATELY NEEDED SPECIFIC INFORMATION)

TOTAL INFORMATION ACQUISITION

Source: National Materials Advisory Board, *Dissemination of /formation on Materials.*

resources to respond effectively to short supply situations that occur with little warning. Because short supply situations were long considered anomalies, coordinated procedures for analysis and decisionmaking had not evolved. and the existing methods were ad hoc and crisis-oriented. In large part. the problem resulted from the multiplicity of departments. agencies and councils involved in formulating policy.

In particular, the study confirmed a view of earl reviews: that unavailability of adequate corn mod it y information had hampered decision making, For some of the (commodities reviewed, necessary supply and demand in format ion was not available, incomplete, or in dispute. Because of fragmented information handling procedures. pertinent information, even when it was available. may not have been funneled to the people who needed it.

Many of these shortcomings also carried over to long-range commodity policy planning. Here, too. the study found that organization and coordination among the involved agencies needed improvement to clarify roles and missions. Throughout GAO's analysis. the importance of effective information systems was stressed:

> Commodity policy analysis. decisionmaking and planning can not be effective if adequate information is not available. Commodity policy decisions can have only limited utility. and may even be counterproductive, if they are' not guided by a set of established long-range policies and extensive data gathering has little value; if the data is not effectively used for analysis. Data gathering. analysis. forecasting. decisionmaking, and planning must be (considered together for the system to function properly (ref. 12).

The GAO study noted that the development of an information system for mineral commodities posed a more difficult challenge than for agricultural commodities. Among the complicating elements are the larger number of minerals for which the United States depends on foreign supply and the inherent difficulty in measuring and projecting resources within the earth (in contrast to those that are visible at the surface). Because of long-term efforts of the Department of Agriculture in developing crop forecasting systems (initially in support of production incentive programs), the in format ion systems for agricultural commodities are more advanced than for minerals. The GAO study concluded that for mineral commodities, "the quantity, quality. accessibility, and interchangeability of data is inadequate for the task of developing natural resources and environmental policies" (ref. 12).

The study emphasized the need for improvements in analytical techniques for interpreting and projecting the data. Citing certain exceptions, e.g., the Economic Research Service (ERS) within USDA. GAO observed that:

> Most of the research and analysis in commodity forecasting is a result of informed opinion rather than such scientific methods as partial simulation models embodying judgment and statistical relationships or fully computerizcd models. . . . Methods used arc generally selected in an ad hoc manner from a variety of sources not programmed by type of inquiry or analysis. The research is not based on a steady accumulation of data and analysis. Agencies. therefore. rely on an individual analyst's expertise. developed within the organizat ion on specific commodities.. and do not build a general data base that can be used as a permanen t record. Relying on such commod i ty expertise hinders the developmen t of stand ads of reliab i1ity and improved forecasting (ref. 12),

Looking to the future. the report noted the growing number of domestic and international factors that affect the severity and complexity of shortage situations and concluded that existing policymaking procedures did not adequately interrelate them.

6. The Federation of Materials Societies Survey

In contrast with the focus of the GAO study on Government systems, this review covered the entire spectrum of materials information systems. Conducted by the Federation of

Materials Societies at OTA'S request, its purpose was to obtain a quick hut comprehensive survey of the breadth and intensity of the materials information problems confronting users. As reported (ref. 13), a questionnaire was designed and sent to some 4,000 professionals having evinced an interest in materials information. About 700 replies were received.[4] The distribution of respondents, shown in figure 111-3, indicates roughly equal representation from industry and universities. with less coverage of Government. Respondents' fields of speciality were predominantly in science and advanced engineering. with less coverage in practical design engineering, and still less in economic aspects. Table 111-2 presents selected results of the survey bearing on four points of particular interest to this assessment. namely:

- Importance of improved materials information systems;
- Perceived needs the improved systems should address;
- How such systems should be institutionalized; and
- How the costs should be borne.

Almost 9 out of 10 respondents judged materials information to be important or highly critical. Fewer than half regarded the present scope of information systems as good, with many noting needs not being served. Two-thirds spoke of deficiencies in quality. and almost half criticized the accessibility of information. The most frequently cited needs related to up-to-date, reliable compilations of data. A smaller number of respondents cited the need for more complete economic statistics and the problems introduced by the proprietary nature of much of this information. A striking point that emerged from the survey was the great diversity of the sources of information that users call on. Asked to name the top four specific sources of materials information that they use, the 688 respondents (not all of whom answered the question) cited 574 different sources. Recognizing the difficulties in satisfying this variety of needs, Westbrook commented "This great diversity of important sources is one of the root causes of materials information problems*' (ref. 13). With regard to improved services, the respondents divided about evenly as to whether they preferred a single national system or a pluralistic network of systems. More than half favored the sharing of the costs of information management among Government, users. and technical societies.

In addition to the responses to the formal questions, an unusually large number of respondents appended comments. Many covered the frustrations met in using the systems;[5] others contained thoughtful suggestions for improving it, Many of these additional comments were considered in this assessment.

7. Prospective Functional Requirements of an Improved System

Analysis of these studies led to the thesis that the Government's ability to deal effectively with shortages needs to be improved. and that such improvement should treat materials information in an integrated. systematic manner. That is, the problem demands a conceptual framework to interrelate the multitude of different factors; data to be collected on each of the factors; and all of it to be so organized. coupled, and analyzed as to display the inherent dynamics of the flow of materials.

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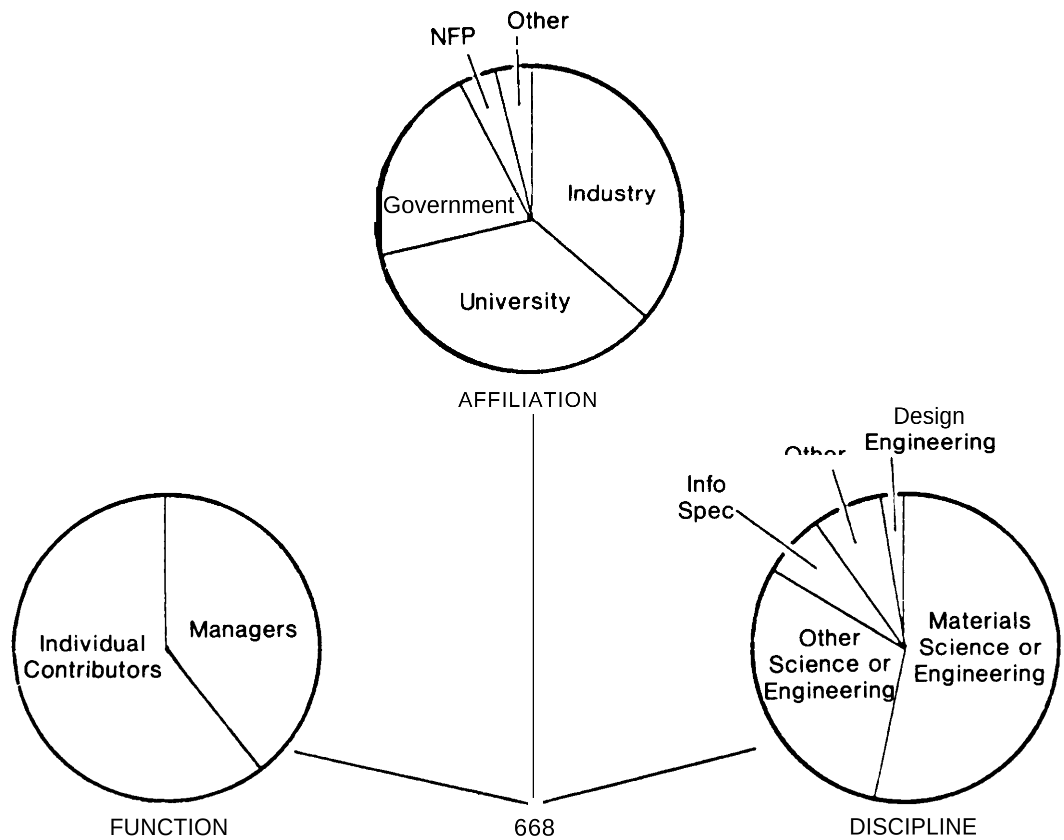
[4]An additional 300 replies received after ref. 13 was prepared were not reported in the analysis.

[5]In this connection, Westbrook's characterization is of interest:

> '*This (materials information) syndrome comprises bewilderment. apprehension. dismay. frustration. and outrage: *Bewilderment* with respect to the enormous volume and diversity of needed sources of information: *Apprehension* as to the quality and reliability y of those facts: *Dismay* at the redundancy. gaps. and lack of coordination between information sources and systems: *Frustration* with the mechanics of search. retrieval and manipulation of information from the general store: and *Outrage* at the cost of seeking and locating needed information" (ref. 13).

Figure III-3. Distribution of Respondents to FMS Survey



Source: J. H. Westbrook, “Materials Information: An Examination of the Adequacy of Existing Systems”.

Table ill-2.—Selected Results of FMS Survey

A — Importance of Improved Materials Information System

Assessment	
Highly critical	36.5%
Important	48.5
Satisfactory	11.6
Attention, selected area only	3.3

B — Perceived Need

Comprehensive, machine readable, continuously updated information system	111
Handbooks, reviews, compilations with critical evaluation and coordination	107
Lag in availability of information	47
Problem of proprietary information	46
Better economic statistics, supply/demand, etc.	42
Problems of coping with foreign information	29

C — Favored Objective

Comprehensive, integrated national system	44.070
Improved present pluralistic system	43.2
No change	12.8

D — Who Should Pay Costs?

Shared	54.270
Government mission agency	22.8
User	17.6
Professional societies	3.5
Other	1.9

Source: J. H. Westbrook, "Materials Information: An Examination of the Adequacy of Existing Systems".

An initial set of prospective functional requirements needed for improving the materials information system was developed. These were then refined through the interview process and subsequent analysis, The functional requirements covered three general areas of materials flow: (1) factors directly affecting supply, (2) factors directly affecting utilization, and (3) factors which indirectly affect both. Table 111-3 indicates those prospective functional requirements cited or significantly implied in past materials studies.

C. REVIEW OF PENDING LEGISLATION

Reflecting considered analysis by Congressmen and their staffs, some 200 bills dealing directly with materials and materials information were introduced in the 93d and 94th Congresses. These bills indicate a recognition of the need for many of the prospective functional requirements, as shown in table 111-4. The bills reflect the view that information management problems such as coordination, compatibility, and dissemination are limiting effective analyses of materials shortages and related environmental problems. The proposed legislation include provisions for improving the collect ion, standardization, analysis, and reporting of materials information, covering information both on the long-term availability of critical materials and on associated environmental problems.

Comparison of the bills introduced in the 93d Congress with those of the 94th Congress indicates that the more recent bills show greater awareness of the need for the supply and utilization functions, It is interesting to note that in response to changing priorities, concern for incorporating an energy function increased. while interest in the environmental protection function leveled off,

D. INTERVIEWS WITH MATERIALS DECISIONMAKERS

The views of a sample of materials decisionmakers regarding the need for and the charac - teristics of improved information system capabilities were obtained through two sets of interviews. The first covered senior level ex - ecutives having policy responsibilities. The

Table 111-3.—Referenoes to Functional Requirements in Principal Materials Studies

Functional Requirements	President's Materials Policy Commission	National Commission on Materials Policy	COSMAT	GAO
supply				
Resources inventory	x	x		x
Reserves inventory		x		x
Industrial stocks	x	x		x
Strategic stockpiling	x			
Economic stockpiling	x			
Import levels		x		x
Recovery/recycle potential	x	x		x
Supply forecasting	x	x	x	x
Utilization				
Production rate		x		x
Production capacity		x		
Consumption rate/patterns	x	x		x
Export levels		x		x
Demand forecasting	x	x	x	x
Indirect				
Price		x		x
Research and development	x	x	x	x
Materials substitution		x	x	
Environment	x	x	x	
Energy		x		x
Investment capital		x		x
Transportation		x		x
Manpower			x	

second covered lower level materials managers concerned with a single. representative material-aluminum.

1. Senior Level Executives

Some 20 senior executives at the assistant secretary level in the Federal Government and 5 similarity placed industry executives were interviewed. Their affiliations and positions are shown in table III-5,

A formal questionnaire was designed and used to guide the discussions; however, the executives' views on all related issues were invited. To encourage the frankest expression of views, it was agreed that individual responses would not be attributed but would be aggregated for publication, Generally, the respondents described the policy questions they were called upon to answer. the information systems they used, and the strengths and shortcomings they experienced in using them, The discussion focused on two related questions: (1) To what extent did the executive see the need for improved materials information capabilities? and (2) What capabilities did they consider most important?

With respect to the nature of materials questions they confront, the majority of respondents cited requests from the department secretary or assistant secretary as being most common. Less frequent were lateral inquiries from other departments or Congress, There, the common pattern of information flow was vertical from the secretary through the specific assistant secretary through the appropriate policy or planning office responsible for preparing the response. In most cases, all information used in answering the request was developed from within the department; seldom did one department go to another for information,

Table III-4.—Prospective Functional Requirements Reflected in Legislation of 93d and 94th Congresses

Functional Requirements	93d Congress																		94th Congress																		
	Senate									House									Senate									House									
	S.424	S.1283	S.2296	S.2782	S.2806	S.2966	S.3625, 3467	S.3954	S.4061	H.R. 6547	H.R. 11694	H.R. 12836	H.R. 15781	H.R. 16006	H.Res. 907	H.Res. 1014	H.R. 9697	H.R. 9698	S.26	S.32, S.79	S.594	S.1410	S.1415	S.1798	S.1864	S.1869	S.2296	H.R. 968	H.R. 1632	H.R. 1668	H.R. 1647	H.R. 2363	H.R. 2365	H.R. 2736	H.R. 4971	H.R. 9212	H.Res. 31
Supply:																																					
Resources inventory	X	X	X	X										X				X				X		X	X		X	X		X			X				
Reserves inventory				X							X			X								X			X			X			X		X				
Industrial stocks				X													X						X		X									X			
Strategic stockpiling																					X	X	X														
Economic stockpiling																	X				X	X	X			X											
Imports monitoring/control					X	X										X							X			X			X								
Recovery monitoring/ recycled materials								X				X					X																				
Supply forecasting			X			X											X	X				X	X	X			X	X					X				X
Utilization:																																					
Production rate						X												X				X	X		X			X					X	X			
Production capacity						X																X	X		X			X						X			
Consumption rate/patterns			X		X	X								X				X				X	X		X			X				X	X	X			
Exports monitoring/control						X				X						X							X														
Demand forecasting (rate of materials demand)			X			X											X	X				X	X	X	X		X	X					X				
Indirect:																																					
Price		X										X		X		X						X	X	X			X	X					X				
New technology		X			X	X			X									X		X		X	X					X					X			X	
Research and development		X	X		X		X		X			X	X						X	X			X	X			X	X		X			X	X		X	
Materials substitution																					X	X		X				X		X							
Environment	X		X	X		X	X	X	X									X	X			X	X				X	X					X		X		
Energy		X		X	X									X				X				X	X		X			X			X		X	X	X		
Investment capital		X	X		X																	X	X	X			X	X					X				
Transportation	X							X				X						X				X	X	X	X		X	X					X				
Manpower						X												X				X	X	X	X												
Consumer product safety/hazards																																			X		
Marketing																						X	X		X												

Table 111-5-Materials Executives Interviewed

Assistant Director for Research, U.S. Geological Survey, Department of the interior
Manager, Material Strategy Department, Ford Motor co.
Director, Federal Preparedness Agency, General Services Administration
Director, Office of Planning and Evacuation, Department of Agriculture
Director, OBRA, Department of Commerce
Senior Fellow, Resources for the Future, Inc.
Director, Bureau of Mines, Department of the Interior
Assistant Secretary for Economic and Business Affairs, Department of State
Assistant Secretary, Land and Water Resources, Bureau of Land Management, Department of the Interior
Former Deputy Director, Washington Environmental Research Center
Senior Specialist, Congressional Research Service, Library of Congress
Deputy Administrator, General Services Administration
Assistant Secretary for Economic Policy, Department of the Treasury
Deputy Assistant Secretary, International Resources and Food Policy, Department of State
Acting Assistant Attorney General, Department of Justice
Head, Energy and Materials Division, Resources for the Future, Inc.
Director, U. S. Geological Survey, Department of the interior
Associate Director, Mineral and Materials Supply/Demand Analysis, Bureau of Mines, Department of the Interior
Vice President, Government Relations; Director of Environmental Services, National Coal Association
Director, Agricultural Economics, Department of Agriculture
Deputy Assistant Administrator, Federal Energy Administration
President, Reynolds Metals Corporation
Former Administrator, Federal Energy Administration
Chief, Trade Resources Division, Department of State
Vice President, ALUMET

The nature of the questions varied greatly. Some recurred frequently; commonly, these concerned commodity reserves, current distribution, current prices, consumption, and the levels of stockpiles. A few respondents indicated that occasionally they are asked to provide specific materials plans, for example, a contingency plan for materials allocation or rationing.

Only a few respondents indicated that they had formalized information systems which they could use to assess policy questions. Some, as in the Bureau of Mines, could call on sophisticated, partially automated systems that were in development. Though it was too early to judge their overall performance, it was already clear that they would likely have some serious limitations, particularly with respect to inadequate data on foreign resources, reserves, production, and consumption. Most respondents indicated that their "systems" were based on commodity experts, who attempted to keep current on all developments in their fields by relying on serial publications of their own and other departments and contacts with industry sources.

About half the respondents, generally those who had need to exchange information outside their own agencies, felt that lateral transfer was inadequate. Sometimes the flow was restricted because, as one respondent said, "people do not want the information used against them. " Often, one agency is reluctant or unable to devote the time and effort required to answer a query from another. A majority of respondents, including those that had no quarrels with lateral transfer, were dissatisfied with the effectiveness of vertical transfer of information, The general opinion was that they received too much rather than too little information. Too much information was being sent forward without summarization or analysis. One executive said. "It takes time and effort and understanding to summarize. It is much easier to send up the complete report rather than extract the information necessary to answer the particular question. Moreover, it's safer. As a result, I'm swamped with reports when what I want is simple answers.

More than half the respondents felt that improved, systems-oriented information systems would enable them to formulate better materials policy. However several, mostly in industry, were troubled by the problems such a system might pose and did not endorse it. Of particular concern were questions on the privacy of information and the possibility that the system might lead to "undue" Government interference in the free market.

Most of the materials executives offered opinons on the functional requirements that ought to be included in an improved system, if it were implemented, These views are summarized in table 111-6,

Table Ill-6_Importance of Functional Objectives as Viewed by Materials Executives

Functional Requirements	Number of Reaponses (of 25)		
	Great Value	Substantial Value	Negligible Value
Supply			
Resources inventory	13	8	2
Reserves inventory	15	7	1
Resources/reserves prediction	7	0	0
Industrial stocks	5	0	0
Strategic stockpile	15	6	2
Economic stockpiles	5	0	0
Rate of imports monitoring	15	6	2
Recycling/potential rate of recycling	15	6	3
Overall supply forecast	8	2	0
Supply/demand monitoring	16	0	0
Utilization			
Rate of production-mlning	14	7	3
Rate of production—extraction	14	6	4
Rate/level of production-fabrication	14	6	3
Rate of exports monitoring	15	7	2
Indirect			
Overall supply vs demand analysis capability	16	1	0
Price forecasting	7	0	0
Research end development monitoring	0	1	0
Residuals (pollutant) production	15	6	2
Land management-multiple use	2	0	0

2. Aluminum Specialists

The second step in the interview process covered 59 materials specialists in industry, academic institutions, and Government, In contrast with the senior executives surveyed in the first step, most of these respondents had more pragmatic, day-to-day management responsibilities. To bring greater focus to this survey, a single material (aluminum) was selected, and respondents were chosen for their familiarity with the aluminum materials cycle and the strengths, weaknesses, and needs of the information systems that support aluminum decision making,

Aluminum was chosen as the representative "test" material for several reasons. First, it is a major domestic commodity, accounting in 1972 for approximately $1.4 billion worth of primary aluminum products. Second, it displays complex dependencies on foreign sources: 90 percent of the ore (bauxite) is imported: also shortage-inducing actions of exporters, akin to those of OPEC, are of concern. (The International Bauxite Association was formed in 1974,) These conditions have resulted in a national awareness of aluminum shortages, As indicated by a 1974 survey conducted by the Senate Committee on Government Operations, nearly **30** percent of the respondents foresaw or were concerned with aluminum shortages, Unlike some materials for which the economy is totally dependent on foreign supplies, the United States has some domestic supplies of bauxite. Moreover, there are also supplies of alunite, anorthosite, dousinite, and kolonite which could be exploited in place of bauxite.

Aluminum also illustrates the range of options and interrelationships that derive from substitution of one material for another. Thus. copper can be substituted for aluminum in many applications, It is already so used in the electrical industry, But, illustrative of the complex interactions at work, this trend could be reversed as a result of increasing energy costs. Other aspects of aluminum that recommended it for the study are its use in Government stockpiles, and the fact that the industry includes an active recycling element.

While the aluminum cycle appears to encompass a large number of the issues of concern with materials generally. it is recognized that no single example is fully representative; follow-on study efforts would well consider additional detailed examples,

In the aluminum survey. respondents were asked about their use of existing materials information systems, the need they saw for an improved system, and the kinds of functions that should be included within such a system. As with the senior executive interviews, these interviews were conducted informally, often by telephone: a written questionnaire was used to set the general direction. but respondents were encouraged to volunteer opinions and percept ions, Table III-7 1ists the affiliation of the respondents, and the areas of emphasis in the interviews: it also summarizes the major characteristics of their materials information systems.

In the public sector of the aluminum community, these information systems are primarily concerned with supply and demand statistics: in the private sector, with technical information. The larger industrial firms have developed in-house information systems covering those aspects of the aluminum cycle of special relevance to their operations. Some, with sophisticated statistical and analytical capabilities. are used to develop economic forecasts. The smaller firms tend to rely on data obtained from the Federal Government and trade associations and do not have substantia1 in-house analytical capabilities. Several respondents noted that often Government data-base managers were not sufficiently aware of how private industry used their reports. A need exists for users to have more input in formulating the content and format of published reports.

The survey indicated that while some systems were automated, most were manual and in almost all cases the respondents relied on primary and secondary 1iterature and on person-to-person exchanges rather than on automated systems. In almost all cases. analysis and interpretation of data bases were performed manually. Several respondents noted that an arrangement of candid, sometimes unofficial, exchanges of information between industry representatives and their counterparts in Government has evolved over many years. They recommended that expansion of the present materials information system should take pains to avoid interrupting these valuable information channels.

The survey found it difficult to assess the quality of the aluminum information systems, There was little agreement on how to rate the systems; few respondents were in a position to assign meaningful quantitative measures, In an attempt to obtain a degree of uniformity in the appraisals, respondents were asked to consider how well their systems could provide answers to the series of very specific representative test questions listed in table 111-8, Using these as a frame of reference, the survey inquired about the completeness of aluminum data bases and their accuracy, Table III-9 summarizes the coverage of data bases as reported by respondents, The most comprehensive bases (covering the complete aluminum cycle) are maintained by the larger industrial firms. The most automated bases pertain to resources and reserves data. Considering the importance of foreign activities in the aluminum cycle, the incompleteness of foreign data is striking.

An appraisal of the accuracy of representative aluminum data bases was obtained from a subset of respondents, all in the public and academic sectors: the results are shown in table 111-10. On the whole, accuracy appears to be high. However, the techniques used to verify the survey are primitive and the estimates are thus only “best guesses. ” Also, as indicated by industrial respondents, errors as small as 5 percent or less can be important.

On the question of the need for a significantly improved information system, 52 percent of the respondents felt that such a system was required, 14 percent saw it as unnecessary

Table III-7.—Information Systems Used by Aluminum Survey Respondents

Company/ Agency Affiliation	Emphasis Interview	Information Systems in Use			
		General Type/Contents	Major Data	Accesibility	Analytical Capability
Industry					
Alumax	Complete aluminum Cycle	Conventional reference files		—	
Alumimum	Complete aluminum Cycle	Manual	Internal trade	Open	None
Aluminum Co. of America	Complete aluminum cycle	Automated; 10 years of industrywide data by quarters	Alcoa, DOI, DOC, Aluminum Assoc.	Proprietary	Statistical, econometric models make 5 and 10 year industrywide forecasts
Anaconda Casting company	Complete aluminum Cycle	Manual statistical	Aliminum Assoc.	Open	
Coors Inc..	Recycling, aluminum Cycle	Recycling statistics;Manual reference flies		—	
Earth Sciences	R&D	Manual	Internal	Proprietary	
Fairfield Aluminum	R&D	Manual	Trade association	Open	None
Foote Mineral Co.	R&D	Manual	Trade association	Open	None
Forest City Foundries	Complete aluminum cycle	Manaul	Trade association	Open	None
General Extrusion	Complete aluminum cycle	Manual	Trade association	Open	None
Howmet corporation	Complete aluminum cycle	Manual statistical system	Aluminum Assoc., DOI, DOC	Open	
Kagan - Dixon Wire Company	Manufacturing	Manual reference files		—	
Kaiser Aluminum & ChemicalCorp.	Manufacturing	Automated; worldwide data	Kaiser, DOI, DOC, Aluminum Assoc,. Foreign Sources	Proprietary	statistical and econo metric models
Norandex Inc	Manufacturing	Manual Industry files; automated company files-	Trade association	Open	None
Revere Brass and copper	Aluminum cycle	Manual statisatical system	Aluminum Assoc., DOI. DOC	Open	
Reynolds	Aluminum cycle	Automated; worldwide data	Reynolds, Dot, DOC, Aluminum Assoc., foreign-sources	Proprietary	Statistical, econometric models for forecasting and requirements
S-G Metals smelting & Refining Co.	Aluminum Cycle	Manual	Trade association	Open	None

Table III-7.—Information Systems Used by Aluminum Survey Respondents (cont.)

Company/ Agency Affiliation	Emphasis of Interview	Information Systems in Use: General Type/Contents	Major Data Sources	Accessibility	Analytical Capability
Southwire	Aluminum cycle	Automated company data; manual industry data	Company, DOI, DOC (Census), trade association	Limited access	Statistical summaries
U.S. Aluminum Corporation	Aluminum cycle	Manual	—	Open	None
Vulcan Materials Company	Aluminum cycle	Manual system on new and old scrap; refining	*American Metal Market, Iron Age;* customers and suppliers; trade journals	Proprietary	Forecasting by regression analysis on limited scale
Wabash Smelting	Aluminum cycle	Manual	—	—	—
Private					
McGraw-Hill — N.Y. (Information, subsidiary)	Financial information, metal prices	Library and automated bibliographies, reference sources	Industry, internal sources	Open	Abstracts, special reports
Oppenheimer & Company	Aluminum cycle, financial data	ADP, aluminum refining, smelting, other	Industry, government	Proprietary	Model outputs for financial use
Trade Association					
Aluminum Association of America	Aluminum cycle, R&D	Manual files	Industry, DOI, DOC, GSA	Proprietary	Statistics, forecasting; world supply and demand, short-term U.S. products
Aluminum Extruders Council	Aluminum cycle	Manual statistical files	—	—	—
Aluminum Recycling Association	Recycling	Manaual secondary industry statistics	Members	Proprietary	Statistics to members
American Diecasting Institute	Aluminum cycle	Manual statistical files	—	—	—
Forging Industry Association	Aluminum cycle	Manual statistical files	—	—	—
National Assoc. of Recycling Industries	Recycling, aluminum cycle	Manual statistical files	—	—	—
Professional society					
ASM Metals Information	R&D; aluminum cycle	Automated library system and abstracts	Trade and professional journals, industry, other societies	Open	Abstracts; special search reports

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Table III-7.—Information Systems Used by Aluminum Survey Respondents (cont.)

Company/ Agency Affiliation	Emphasis of Interview	Information Systems in Use			
		General Type/Contents	Major Data Sources	Accessibility	Analytical Capability
University					
Georgia—Institute of Technology	Substitute ores	Manual files on aluminum	U.S. DOI BOM, USGS and industrial contacts	Open	—
Montana School of mines State Bureau of Mines & Geology	Substitute ores	Developing a CRIB file on state minerals. USGS will keypunch and will enter in DOI CRIB system	—	—	—
University of Utah	Substitute ores	Manual	U.S. DOI BOM, USGS	Open	—
Not-for-profit					
Battelle Memorial Institute	Materials substitution and selection	Pilot automated materials properties system; various abstracting systems	Multiple literature sources	Limited	Various
State government					
Alaska	Minerals	Automated system on mines, petroleum, but no mineral files	State	Open	Selected file output
Arizona	Substitute ores	Automated system on land leases only	State	Open	Selected file output
Arkansas	Aluminum cycle	Conventional statistical files	U.S., DOI BOM, USGS	Open	—
California	Substitute ores	Conventional files on minerals and mines	—	—	—
Colorado	Substitute ores	Manual files only on resources	—	—	—
Georgia	Aluminum cycle, substitute ores	Conventional files	U.S., DOI BOM, USGS	Open	
Illinois State government N.E. Illinois Planning Comm. Chicago	Substitute ores, waste	Conventional files on natural resources	—	Open	—
Iowa	Substitute ores	Manual statistical files	—	Open	—
Maryland Management Information Systems Division	Substitute ores	Automated system on natural resources, but not for materials	Multiple	Open	Selected file output
Montana State Dept. of Natural Resources	Substitute ores	Automated system on land, river, dams, but no files on minerals	—	Open	
New Mexico	Substitute ores	Manual files on resources	—	Open	—

Table III-7.—Information Systems Used by Aluminum Survey Respondents (cont.

Company/ Agency Affiliation	Emphasis of Interview	Information Systems in Use			
		General Type/Contents	Major Data Sources	Accessibility	Analytical Capability
Federal Government					
Department of Commerce	Aluminum cycle	Manual monthly statistics, metal stocks of domestic producers, etc.	DOC (Census); Bureau of Domestic Commerce	Open	Publications; commodity statistical reports
Department of Commerce, Bureau of Census, Foreign Trade Division	Aluminum cycle	Automated; all import-export commodity data on monthly basis; retained 3 years tape, then microfiche	DOT, Customs Bureau	Open	Monthly statistical reports
Department of Commerce, Bureau of Domestic Commerce	Aluminum cycle	Automated; monthly statistics from aluminum producers and importers	280 aluminum producers and importers	Proprietary	Monthly statistical reports, special reports to federal agencies trade associations, and universities
Department of Interior, Bureau of Mines (BOM)	Aluminum cycle, R&D	Comprehensive automated and conventional system	Industry, other agencies, in-house experts	Open	Serial publications; commodity reports
BOM Div. of Econ. Analysis	Aluminum cycle, R&D	Statistical files; relies upon BOM commodity specialists to supply required data	BOM commodity specialists	Open	Economic forecasts in response to staff requests
BOM, Import-Export	Aluminum cycle	Manual statistical files on bauxite imports and aluminum exports	DOC Bureau of Census, Foreign Trade Division	Open	Support to BOM commodity specialists
BOM, Office of Statistics	Aluminum cycle	Automated; data acquired by BOM commodity questionnaires – mineral industrial surveys on over 200 minerals and materials; in process of developing data file on worldwide aluminum plant capacity to include: source of power, source of bauxite, source of alumina plant production with 10-year projection	Questionnaire to selected industries: bauxite consumption (177-A); bauxite production (20-Q); alumina (30-A); aluminum (31-M); aluminum scrap (82-A)	Proprietary	Routine periodic and special purpose statistical support to BOM commodity specialists
BOM World Production Tech. Data Services	Aluminum cycle	Manual statistical files; world production of bauxite and aluminum ingots, etc.	U.S. Embassies, Dept. of State; foreign and domestic publications	Open	Annual reports
USGS	Aluminum cycle automated files	Worldwide data in report form, USGS bulletin 1228, 1968 is being updated; automated files; (CRIB), worldwide	Multiple sources	Open, limited access	Publications; CRIB file output; statistical output using STATPAC

Table III-7.—Information Systems Used by Aluminum Survey Respondents (cont.)

Company/ Agency Affiliation	Emphasis of Interview	Information Systems in Use			
		General Type/Contents	Major Data Sources	Accessibility	Analytical Capability
Environmental Protection Agency	Environment	Automated system on pollutants and energy production by point source	Industry	Open and proprietary	Statistical printouts
Federal Energy Administration	Energy	Automated system	Industry, DOI BOM	Open, limited access	In development
General Services Administration	Stockpiles	Semiannual report	Internal data	Open	Semiannual report to Congress and various agencies
National Science Foundation	R&D	Automated management information system; conventional files	Internal data; interagency exchange	Open	Publications

Table III-8_Representative Test Questions

Resources:	What are the national resources of bauxite (the primary ore of aluminum) or alunite, kaolin, anorthosite (substtute ores for bauxite)?
Reserves: (Primary Ore)	What are the reserves of bauxite in Jamica (in Arkansas) vs. price?
Reserve (Substitute Ore)	What are the reserves of kaolin in Georgia (alunite in Utah) vs. price?
Mining-Production:	Where are bauxite mining operations located and how much do they produce? How much bauxite is produced in the United States by Company and by state?
Refining:	How much alumina is refined by state and by what processes?
Production-Capacity:	How much aluminum is produced in the United States and by what companies? What capacity do the producing companies have? By state?
Fabricated Products:	How much of a particular fabricated product is produced by a given company or within a region? (Fabricated product here means castings, plate, sheet, rod, extrusions)
Consumer Products:	What consumer products are manufactured by type?
Value:	What is the value added at each (or any) stage of the aluminum cycle?
End Products:	What is the aluminum content of consumer end products?
Manpower:	What is the complement of personnel for various plants?
Capacity:	Is data available concerning plant capacity versus dollar investment and time to construct ?
Service Life:	What is the service life of various consumer products?
Material Selection:	For aluminum with given physical, mechanical, or chemical properties, what are the alternative metals?
Toxicity:	What are the toxic properties of any aluminum alloy?
Environment:	What quantities of residuals are produced in aluminum process (e.g., red mud from refining ?
Energy:	How much energy is consumed at each (or- any) stage of the cycle? How much energy is used to produce the giver! fabricated product [eg., casting, plate, or extrusions)?
R&D:	What aluminum-related R&D activities are in progress for each (or any) part of the aluminum cycle?
Recycling:	How much of the aluminum produced by a given company or within a given geographic area is from recycled material?
Recycling:	How much new scrap is produced by state ?
Transportation:	What is the availability of railroad transportation to a plant, deposit, etc.?

and/or undesirable. and 34 percent were undecided as shown in table 111-11. Respondents in the Federal sector showed the highest percentage favoring such a system, followed by respondents in academic institutions. More than two-thirds of the State government respondents were undecided; however, their principal concern was that the costs to implement and operate the system might exceed their available resources. Respondents from the business community were most equivocal: 35 percent saw no need and another 18 percent were undecided.

Almost all respondents were mindful of and concerned about the possibility that an improved materials information system might be misused to "manage" the American market system. They were similarly concerned about providing sensitive data to an overall open system.

Table III-12 summarizes the important functions of an improved system that were identified by the different categories of respondents. The most commonly stressed functions directly related to improving supply and

Table III-9.—Reported Coverage of Aluminum Data Bases by Component of the Materials Cycle

Contact	Resources	Reserves	Mining	Import Export	Refining	Smelting	Fabrication	Manufacturing	Consumption	Recovery	Stockpile	Inventory	Sample Size
Dept. of Commerce	–	–	–	A-D	–	A-D	A-D	A-D	A-D	A-D	–	A-D	3
Dept. of Interior	A-W/ M-W	A-W/ M-W	A-D/ M-W	– M-D	A-D/ M-D	A-D/ M-D	A-D/ M-W	A-D/ M-W	A-D/ M-D	A-D/ M-D	– M-D	A-D/ M-D	7
GSA	–	–	–	–	–	–	–	–	–	–	A-D	–	1
State agencies	–	–	–	–	–	–	–	–	–	–	–	–	12
Industry, large	–	A-W	A-W	A-W	A-W	A-W	A-W	A-W	A-W	A-W	–	A-W	4
Industry, small	–	–	–	–	–	A-D	A-D	A-D	–	A-D	–	–	20
Trade associations	–	–	M-W	M-D	M-D	M-D	M-W	M-W	M-W	M-W	–	–	7
Universities	–	–	–	–	–	–	–	–	–	–	–	–	8

M – Manual A – Automated D – Domestic W – Worldwide

Table III-10.—Accuracy of Aluminum Data Bases

Category	Estimated Accuracy (Ye)	Source of Estimate
Resources		
Alunite and Aluminum-bearing clays	50	DOI–USGS
Kaolin	60	Georgia Inst. of Technology
Reserves	Uncertain	DOI–BOM
	90	State of Georgia
Mining	90	DOI–BOM
Refining	90	DOI-BOM
Smelting	95+	DOC
Fabrication	95+	DOC
Manufacturing	95+	DOC
Consumption	95+	DOC
Recovery	95+	DOC
Stockpile	95+	GSA
Import–Export	95+	DOC
Worldwide Production & Trade	80	DOI–BOM
Energy	80	Battelle (for BOM)

demand projections. Like the senior level executives interviewed, they also saw the need for the indirect functions. Table 111-13 shows the comparative level of their concern, vis-a - v is those expressed by the senior executives.

E. FOREIGN MATERIALS INFORMATION SYSTEMS

An indication of the status of several foreign government materials information systems was obtained through limited discussions with system designers and planners in Canada, Japan, France, the Organisation for Economic Cooperation and Development. and the International Institute for Applied Systems Analysis. As in the United States. most of the foreign systems are oriented toward development of comprehensive data bases on materials properties and provision of 1ibrary - type abstracting and searching services, rather than toward support of such policy issues as shortages.

One of the most comprehensive systems is that operated by the Centre for Geoscience Data in the Canadian Department of Energy, Mines and Resources. The Centre is the focal point for inquiries and cooperation among

Table III-11.—Aluminum Community Perceived Need for an Improved Materials Information System

Segment of Aluminum Community	Anticipated Need for Improved System			Factors Cited Prompting No/Undecided Responses
	Yes	No	Undecided	
industry	10	8	4	Additional burden of complying with new reporting regulations. Additional cost would not justify small gain to business Concern for increased government involvement in business Trade association and government supply satisfactory data for present needs
Universities, not-for-profit	9	—	5	Undecided until service costs are established
State government	3	—	7	Lack of funds to utilize such a system
Federal Government	7		3	Concern that data bases might be taken from operating agencies

government, universities, and industry, It maintains an index of reports, maps, and data files which it publishes annually. It also attempts to monitor research and development. It has taken the lead in developing standards for reporting geoscience data on mineral and fuel deposits, In its current configuration, index entries are performed online through computer terminals which are located throughout the country. Future plans look to full online interactive access, for input and output. In addition, consideration is being given to expanding the coverage of mineral and fuel types.

In Japan, the country's heavy reliance on foreign raw materials has spurred development of materials analysis techniques. The principal agency responsible for monitoring industrial activities, forecasting industrial outlook, and developing industrial development plans is the Ministry of International Trade and Industry (MITI). Because of the traditionally high level of industry/government cooperation, MITI is able to acquire inventory and production statistics that are considered to be highly reliable, MITI is actively developing econometric models for interrelating production factors and making forecasts; however, it appears that much of this work is still in the experimental stage.

With regard to scientific and technical information, the Japan Information Center of Science and Technology acts as the central organization. The Center carries out collection, regulation, and dissemination of information. It selects important articles, records and classifies them, associates key words, and generates secondary information, The Center also acts as a channel for the exchange of scientific and technical information with other countries. To improve these operations in the face of growing volume, diversity, and demand for information, the Science and Technology Council has developed an approach for a new system called NIST, the National Information System of Scientific and Technical Information, NIST will systematically integrate various existing information collecting organizations into a nationwide network. Increasing emphasis will be placed on participation in international information exchange activities. As currently envisioned, NIST would comprise a central coordination function for the efficient operation of the system as a whole; a processing function to carry out specialized data collection and data processing; and a service function to handle contacts with users, i.e., receive various inputs and furnish information. The processing function, in

Table III-12.—Functional Requirements Cited by Aluminum Specialists

	Segment of Aluminum Community															
	Industry							Academic		Government						
Functional Requirements	Primary Producers	Secondary Industries	Small Business	Other Business	Industry R&D Fac.	Financial Institution	Trade Associations	University	Not-for-Profit	States	USGS	BOM	GSA	DOC	NSF	Federal Research Fac.
Supply																
Resources inventory	×						×			×	×	×				
Reserves inventory	×									×		×				
Strategic stockpiling	×	×					×						×			
Economic stockpiling	×	×				×	×						×			
Industrial stocks	×	×				×	×									
Imports monitoring/ control	×	×				×						×		×		
Recovery monitoring/ recycled materials	×	×		×	×		×					×	×			
Supply forecasting	×		×	×	×	×	×		×		×	×				
Utilization																
Production rate	×	×	×									×				
Production capacity	×	×	×									×				
Consumption rate/patterns	×	×	×	×										×		
Exports monitoring/ control	×	×	×											×		
Demand forecasting (rate of materials demand)	×	×	×	×	×	×	×		×			×				
Indirect																
Price	×			×								×	×	×		
New technology	×							×	×						×	×
Research and development	×	×			×		×	×	×	×	×	×			×	×
Materials substitution									×							
Environment	×				×		×		×	×		×				×
Energy	×				×				×	×	×	×				
Investment capital	×	×														
Producer inventory (location, etc.)					×	×	×							×		
Transportation Manpower	×			×	×	×	×					×				
Consumer product safety/hazards	×				×		×		×		×	×				
Marketing	×	×	×	×			×						×			

Table III-13.—Level of Concern for the Indirect Functional Requirements

Additional Functional Objective	Senior Policymakers (Government and Private)	Aluminum Materials Community (Government and Private)	Aluminum Business Community (Industry Only)
Price and forecasting	Critical	Critical	Critical
Research and development	Critical	Critical	Critical
Materials substitution	Serious	Serious	Serious
Energy	Critical	Critical	Serious
Environment	Critical	Serious	Serious
Capital investment	Serious	Serious	Critical
Transportation	Moderate	Serious	Critical
Manpower	Moderate	Serious	Moderate
Producer inventory	Serious	Moderate	Serious
Marketing	Moderate	Serious	Critical
Consumer product safety	Moderate	Moderate	Moderate

Notes:

Critical — functional objective must be addressed in improved system.

Serious – functional objective deserves strong consideration as an important part of an improved system.

Moderate — concern expressed by only a few respondents; deserves attention as functional objective after critical to serious functional objectives are addressed.

particular, would require high-level data processing methods using computers for collection, regulation, analysis, evaluation. and forecasting. The NIST plan is still under study by the Government.

In France, scientific information related to materials, particularly geological information, is collected, organized, and entered in a semiautomatic information system. In addition, much other technical information concerning materials (e.g., the engineering properties of materials, or data derived from original data in the data base) is already maintained in data banks. Data banks in some 50 technical centers are very detailed as far as engineering properties are concerned. The most complete is that developed for the building industry; it is fully automated and provides information on all the materials used in the building industry. As in Japan. because of the close relationship between industry and the Government, data for these data banks are easily obtained and is considered to be very reliable, Although much material based on this data is published, full access is restricted to individuals and organizations within the Government.

The Canadian, Japanese, and French representatives all expressed interest in an improved information system to address materials-related issues and expressed the view that such a system would fill important international and national needs. Its international aspect was echoed in the discussions held with the Organisation for Economic Cooperation and Development (OECD) and the International Institute for Applied Systems Analysis (IIASA). OECD representatives stressed the need to orient any improved system to user requirements, Because of the difficult technical problems in effectively coupling supply and demand data, they stressed that the information system concept should be limited in what it addressed, particularly in its early form. Further, they emphasized the need in fashioning such a system to build it top-down, demand-driven. Otherwise, those affected would be likely to maintain that change was unnecessary, un -

desirable, or impossible and would resist all innovation or modification. Currently. OECD collects materials data from many countries. catalogs it, and provides information and data (even copies of tapes) to countries requesting it. From time to time it has undertaken original studies relating to materials management (e. g.. Implications For industry of **Changes** in the Availablitity of Energy and Raw Materials and Their Prices, DSTI/IND/75-04 OECD).

The IIASA representative indicated that the international organization had need for a materials information system of the kind discussed, but that at present lacked funds for such a development. IIASA is planning to develop a model of world energy supply, demand, and use. IIASA considers that standardization of data as a means of interrelating relevant data held in diverse data banks ought to be a principal objective.

F. IMPROVED FUNCTIONAL REQUIREMENTS

Based on the composite findings of the literature review, the analysis of the interviews and, to a lesser extent on foreign contacts. a set of functional requirements that should be satisfied in an improved materials information capability was developed. Many of the functions were cited in these sources: others were newly identified. The set covered three kinds of factors: those that directly affect supply: those that directly affect utilization: and those that indirectly affect both.

1. Functional Requirements-Supply

These include:

- Ability to monitor and project inventories of resources.—Resources are the concentrations of natura11y occurring material deposits in or on the earth's crust. The principal data elements are the quantity of materials existing in specific deposits, their locations, grade of the ore, and site characteristics (overburden, deposit area. and thickness).
- Ability to monitor and project inventoric.s of reserves.-Reserves are those portions of the identified resources from which usable minerals and energy commodities can be economically and legally extracted at the time of the determination, Specific materials resources are classified as reserves if they are economically com - petitive with other materials in the marketplace. A controlling factor in determining reserves is the cost of extraction. Thus. a technological breakthrough that substantially reduces the extraction costs of an ore hitherto not considered economically minable could drastically change the quantity of reserves. Accordingly, the principal data elements of concern are those related to quantity and extract ion costs, i.e., basic reserves information for each material must be provided in terms of the current estimate of reserves at specified costs of extraction.
- Ability to monitor and project industrial stocks.-Stocks cover material in process and stored for normal future use, including both raw and finished products. Data elements are concerned with the quantities, types, and locations of inventories.
- Ability to monitor and project inventories of strategic stockpiles.—Stockpiling refers to the diversion (from any part of the materials cycle) and temporary storage of materials to maintain a supply that can be used to avert critical shortages caused by natural or man-made supply interruptions. In accordance with legislation, a strategic stockpile has been maintained by the General Services Administration to maintain sufficient supplies of materials that affect national defense. The data elements required for strategic stockpiles are the quantity of materials, their nature (ore, semifinished,

finished), and the rates at which they approach or depart from their objective levels.

- Ability to monitor and project inventories of economic stockpiles.-In contrast with strategic stockpiles, economic stockpiles seek to effect better materials distribution for peacetime public purposes. Although none has yet been implemented, the concept is under consideration. The data elements are similar to those of strategic stockpiles; however, since their effectiveness and operation are more intimately tied to price variations, they need to be monitored more frequently.
- Ability to monitor and project levels of imports.—Understanding the changing patterns of imports is clearly important to private and public materials managers. The key data elements are quantity of materials imported, their nature (ore, semifinished, finished), and rate of importation.
- Ability to monitor and project the level of recycled material s.—Material that is recovered (and recoverable) from discarded products is becoming increasingly important as a source of supply. Recovery occurs in many phases of the materials cycle. Runaround scrap is the intraplant recycling of scrap material in fabricating plants. New scrap is that material recycled to fabricating plants from manufacturing operations. This material is generally clean and can be readily used by primary mills; old (or dirty) scrap is that material recovered from used end products. The data elements necessary to monitory recovery include the product descriptor (item, material, the location of the scrap, by district and site), its quantity, and data on recovery costs.

  Potentially recoverable materials refers to that materials for which technology exists for separating specified materials from used end products, but for which costs preclude practical recovery at this time. Irrecoverable material is that material in end products for which a recovery technology does not exist. To determine the recycling potential of materials in current use and to analyze the impacts resulting from changes in recovery patterns, the required data elements are the recovery capability of materials by end product, by industry, and by geographical region.
- Ability to forecast total supply.—Total supply is the aggregate of materials in reserves, materials in stockpiles, materials being imported, and materials recovered after use. The reserves provide an indication of long-term supplies; imported and recovered materials together with stockpiled materials constitute short-term supplies. The ability to combine current and forecasted levels to achieve meaningful estimates of total supply depends on developing consistent units of measurement, taking into account possible temporal differences among them.

2. Functional Requirements-Utilization

These include:

- Ability to monitor levels of materials being produced and producible.—Production is the process of converting natural deposits into marketable products, i.e,, transforming primary ores to intermediate products to manufacturing of end products. Production capacity refers to the amount of materials that could be produced at each production step if the Nation's plants were fully utilized. Knowledge of available production capacity is needed to assess the ability of domestic production facilities to expand as needed.

  The required data elements vary with each stage of the materials cycle. For mining, for example, they cover location (to site level), characteristics of the products and byproducts, quantity of each product and byproduct, supplies used (energy and materials), resources needed to build. maintain, and operate the plant, and related economic data, For manufacturing, they cover the materials in end products, location (special districts and site level), capacity, quantity and types of byproducts, supplies used (energy and materials), resources required, and economic data,

- Ability to monitor levels of materials consumed in end products.-This refers to the rate of consumption of materials delivered to consumers. Of prospective concern is the amount of a specific material contained in each product, the product service life, and the manner in which the material is incorporated in the product. Although few such statistics are now available, they could be important for efficient recycling and product disposal. Data elements for the consumption component are the product (market category, Standard Industrial Classification, and item), location by special districts and site, and the quantity produced.

- Ability to monitor levels of exports. -As with imports. understanding patterns in materials exports is clearly important. The rate of exports reflects the ability of domestic firms to compete with other nations. Increasing exports of critical materials (as materials or products) is of concern to materials managers because of the possibility of domestic shortages and/or increased domestic prices. With effective monitoring and forecasting. suitable actions might be taken to minimize these potential impacts. The data elements needed for monitoring exports are similar to those for imports.

- Ability to forecast total demand-This refers to the ability to project total demand, aggregating future domestic requirements, and export opportunities. Although inherently difficult (the Paley Commission projections are a case in point), this capability is essential for anticipating potential shortage situations.

3. Functional Requirements-Supply/ Utilization

The initial set of prospectively useful functions also called out a series of other capabilities having to do with interrelateing price effects and several other factors. These include:

- Ability to merge separate supply and utilization information to forecast the impact of price on supply and demand.-Changes in the market price of a product clearly can change the supply available and the demand for it. In the past it was generally assumed that supplies of materials for products in demand would become available with suitable price increases. Recent events have shown that this may not hold under conditions of scarcity. Each material has a unique supply and demand price elasticity. whose range depends on a complex array of factors. Observing and recording changes in supplies, demands, and prices of critical materials could aid in developing improved methods for quantifying their relationships.

- Monitoring research and development programs. -This capability refers to improving the availability y of information on current materials research and development and maintaining data on new technology which might impact the availability of critical materials, A 1 ink between knowledge of the broad range of existing R&D programs and awareness of materials problems is essentia1 to materials management policy; often new R&D programs must be implemented and other programs redirected. A better information mechanism might increase the effectiveness of Government R&D programs by ensuring that they address critical materials problems, Data elements for monitoring materials R&D activities include a registry of experts in materials science and engineering and the status of materials research programs.

- Aiding in selection of substitute materials.-This refers to the complex process by which users of materials select one material over another and modify their choices as a material comes into short supply. Materials policy planners, as well as engineers and producers, need to understand the options available for substitution. The process is fundamentally dependent on the availability of information,

- Monitoring environmental impact and energy use.—This capability refers to analyzing the consequences of implementing environ mental protection programs, including the use, elimination, and replacement of specific materials, and to the analysis of the energy consumed by processes in the stages of the material cycle. Data elements for environmental monitoring include pollutant by type, amount per unit production, and media for disposal; for energy use, they include energy consumption by manufacturing process per unit production and by end product when used by the consumer,

- Monitoring availability of investment capita l.—As demonstrated by Cooper's analysis of the Paley Commission projections, the availability of investment capital is a fundamental variable in projecting future suppliers. Information elements on the relevant variables might be assembled which would enable analysts to get a better handle on this factor,

- Monitoring and projecting availability of transportation.—Transportation capabilities significantly affect materials supplies. Information on current and future capabilities are required.

- Monitoring and projecting availability of manpower.—Availability of a trained labor force can have direct bearing on materials policy options. Information on current and projected levels are needed.

G. INTEGRATION OF FUNCTIONAL REQUIREMENTS

Perhaps the most important finding of the literature review and the interviews was that materials decision makers need to interrelate more effectively the various elements of data available to them. They require an information system structure that displays the interaction of the many factors determining materials flow through the cycle, even more important than obtaining more complete data. In effect, the improved capabilities needs to be organized to illuminate the dynamic flow of material through the materials cycle. Such an organization could indicate the availability of a material at each stage in the materials cycle, By examining the flow pattern, i.e., by having information and analysis of conditions at each stage in the cycle, the Federal policy maker could determine the severity of a problem and, if it were sufficiently serious, how it might be averted or relieved and at what cost.

These operational characteristics are akin to those that occur in many physical control systems, In an electrical distribution system, for example, input disturbances (perhaps a sudden increase in demand caused by a summer heat spell) are continuously monitored and compared with system capacity. The difference is used to signal or trigger corrective actions, such as putting another generator online or drawing additional energy from another power pool. In dealing with dynamic, physical problems, one must first characterize the control system i.e., describe how the individual elements within the system affect each other, For example, how do weather conditions affect demand, or how does capacity vary with the number of generators online, These interrelationships are the so-called subsystem transfer functions, The control system is normally represented in the form of a func -

tional block diagram in which the blocks depict, in mathematically precise form, the action of each element in the physical system.

The dynamics of material flow and the control options for dealing with disturbances to normal flow are more complex than for most physical systems. Monitoring all the relevant variables is clearly more difficult, as is defining the various interrelationships in precise, mathematical form. Yet the principle is essentially the same, and the block diagram concept is useful for describing the way the individual functions can be usefully organized,

Figure III-4 is illustrative, The individual blocks in the diagram depict information requirements at each stage in the materials cycle and correspond to the functional requirements described earlier. The arrangement of the blocks and the way they affect each other simulate the overall behavior of the materials system. The level of detail required in such a functional block diagram depends on its intended use. For providing aid to Government policymaking, the data can be aggregated to a high level and the number of functional blocks and interrelationships can be kept to a relatively small number.

The simplified diagram describes the flow of a single material; in actual practice, it would comprise a similar set of interconnected functions for each critical material to be covered. The block diagram may be viewed as another way of depicting the flow of materials through the materials cycle: it simply superimposes on the physical flow of material the flow of the information that directs it.

The blocks are of three kinds: those that depict considerations affecting supply; those that depict utilization considerations; and those that treat their interrelationships.

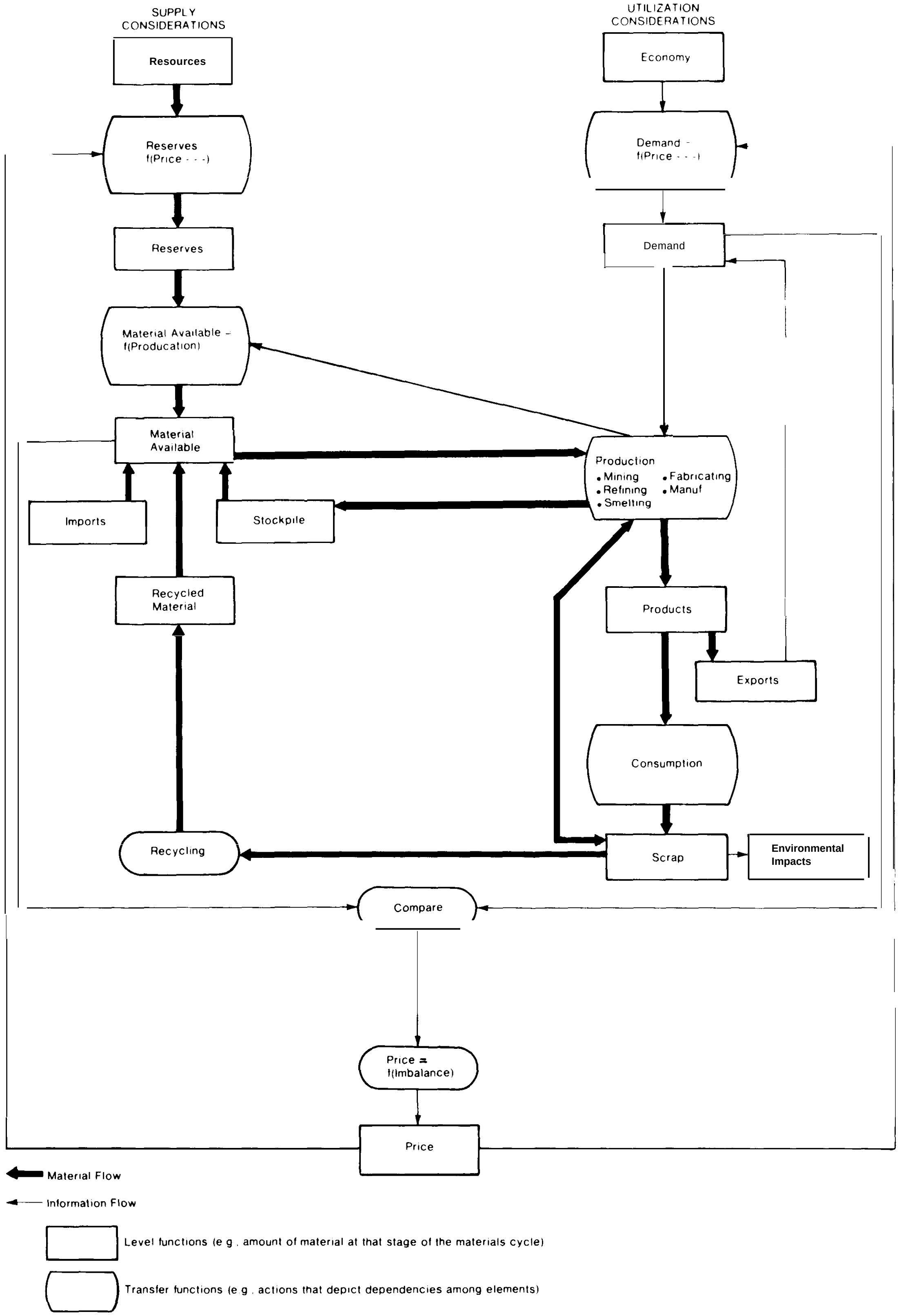
1. Supply Considerations

The first supply considerations shown in figure III-4 are the functional capabilities for monitoring and projecting levels of resources and reserves, As an improved set of in formation capabilities might be organized, this information might be collected and held in multiple, compatible data bases, As with other data bases implicit in this kind of framework, it is not required that all of this information be held in one place, only that it be so organized, standardized, and aggregated that all of it can be accessed when needed by authorized users. The framework also shows the capability to determine levels of materials made available through production processes, This function accounts for the levels of materials processed from reserves; these, in turn, depend on the level of plant capacity employed and other factors.

Other supply considerate ions, shown in figure III-4 include the capability to monitor and project levels of normal industrial stocks and any strategic and economic stockpiles maintained by the Government, This information would be stored in appropriate standardized data bases. Similarly, the framework would monitor imports and incorporate techniques for projecting future foreign supplies. Such unpredictable perturbations as embargos might be handled by building in blocks corresponding to different sets of contingency scenarios. The framework would also monitor and project levels of materials that become available through recycling. All of these contributions to supply would be appropriately summed. The organization would thus continuously monitor and project total materials availability y.

Two functionally different kinds of supply blocks are shown in figure 111-4. The rectangles show the levels of supplies in their various forms, for example “resources”. The rounded rectangles represent transfer functions which depict the dependency of one element on another. Thus, the box marked “Reserves = f (Price. . .)” indicates that resources become reserves through the pricing mechanism: as prices increase, subeconomic resource become economic to mine and thus add to reserve levels.

Figure III-4.—Basic Framework for Interrelating Elements of Materials Information



2. Utilization Considerations

Figure III-4 also incorporates the capability to project the demand for a critical material. In general the demand is a function of the price of the material and a host of other factors, including the level of general economic activity. The demand for a material. covering both its domestic and export components. determines the productive capacity to bring that supply into being. The project ion transfer function merges information on alL phases of activity involved in transforming ores into useful products. Examples of information associated with the product ion function include (1) the quantity of the primary material at each stage of production: (2) other materials used or produced (including waste products and by-products): (3) employment; (4) existing plant capacity: (5) lead time and cost for construction of new capacity; (6) transportation requirements: and (7) energy requirements.

The output of the production function are products, i.e., the end-use item(s) designed to fill specific consumer needs. By organizing information monitoring and projecting the consumpt ion patterns of a product, such as the useful 1ife and recyclable material content, the in formational framework is able to monitor and predict the available amount o f recycled material. As indicated in figure III-4, recoverable material also flows in forms of scrap from wastes generated in the production process. On the negative side. waste disposal is conceptually depicted as presenting environmental impacts which, in turn, affect the production function, price, and ultimately demand.

3. Supply/Utilization Interrelationship and Management Actions

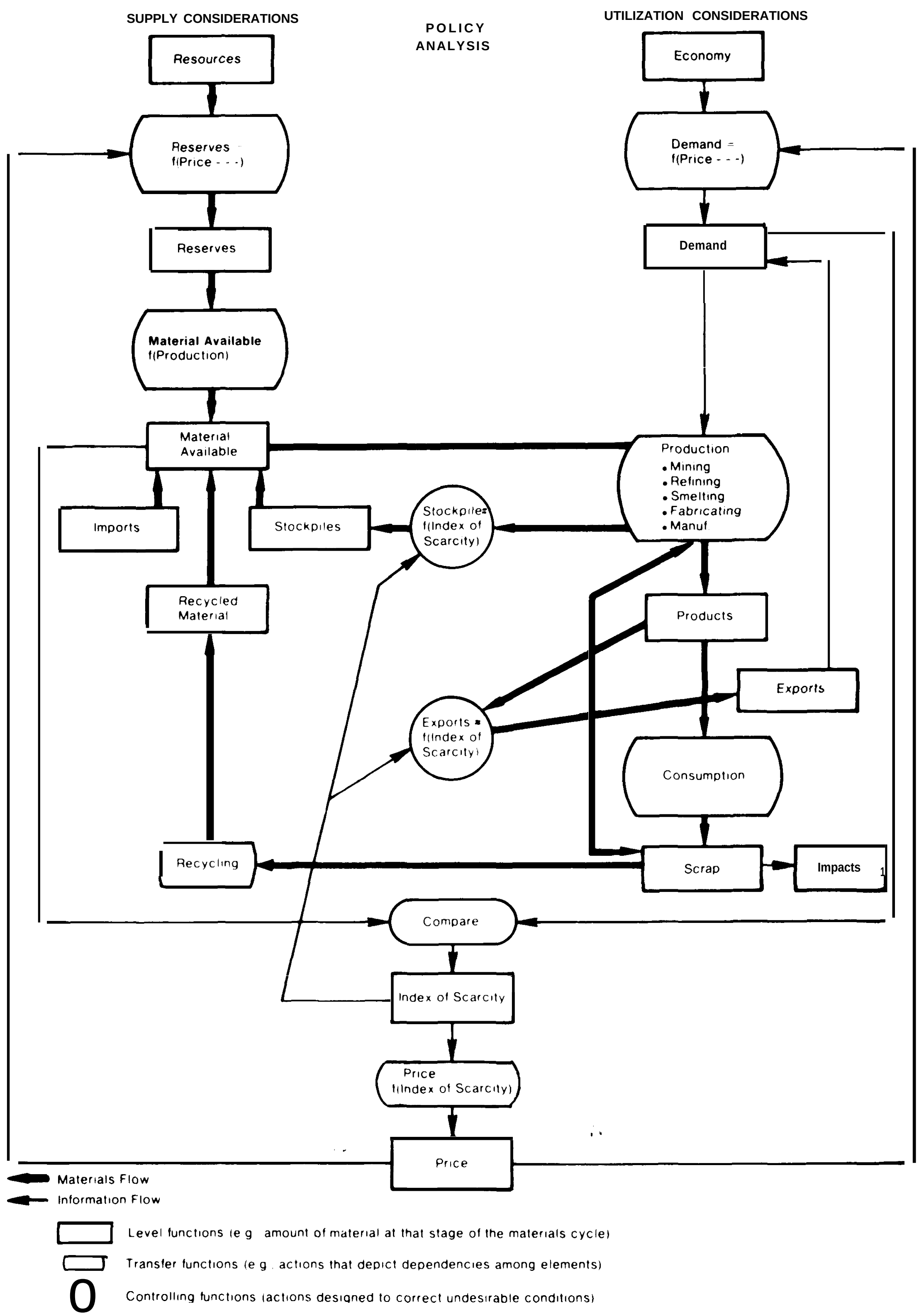
Also depicted in figure III-4 is the principal control act ion of the market system, the pricing mechanism. The framework compares material supplies with demand and adjusts price accordingly, feeding back the price incremen t to each block having a price sensitivity. Under normal conditions the pricing mechanism works to maintain a continuous flow of material through the cycle. However, if it does not, policy makers in the Government must decide whether or not action in the public interest is required. The improved functions and organizational framework would support this decisionmaking process by assessing the impacts of alternative policy options upon the flow of materials through the economic system.

Before using these improved capabilities, careful distinction should be made between three separate, though sequentially dependent, steps in the overall decisionmaking process: (1) data gathering and analysis, (2) policy analysis, and (3) policymaking. The improved capabilities might provide the capabilities to achieve the first two steps, but it would in no way attempt to achieve the third. Policy decisions would in all cases be the responsibility of the policy maker. The integrated framework would merely support his decisions. first. by collecting and analyzing data, and second, by using the data and analysis capability to address “what if” types of questions.

In depicting the internal control behavior of the market, as shown in figure 111-4, the framework would itself be an extremely useful analytical tool. However. its real value is its capability to provide information and analysis for policy makers to use in assessing the effectiveness of policy options the Government might take to relieve serious d islocations, Two examples of Government policy actions are shown in figure 111-5, One relates to Govern - ment stockpiles: the other. to the use of export controls as a means of addressing materials shortages,

In assessing whether a stockpile policy could avert or alleviate a shortage, Government policy makers could use the integrated capabilities —the individual functions and their organization along the lines of the framework—to test its effectiveness. The framework, in effect, provides the means for simulating its rippling effects on the materials system, By examining the benefits and costs of the stockpile policy, and by comparing this in-

Figure III-5.—Basic Informational Framework Showing Selected Policy Actions



formation with similar analyses of other relevan t policy options, the Goverment decision - maker could determine what policy, if any, might be required to solve the material problem. The analysis might well indicate that no Government action is required, and that the market system will self-correct.

The same kind of "testing" can be used for assessing Government actions with regard to export controls. also shown in figure III-5. Export embargos, an extreme form of export control, were implemented in the 1972–74 period, but for only short periods. They were hastily applied and hastily lifted, in part because their impacts, both positive and negative. on the materials flow pattern were imperfectly anticipated, By organizing all the relevant data and showing the interrelationships and feedback effects. the improved in formational capabilities could present a fuller picture of the impacts of such actions. The framework might enable more effective use of export controls; or it might show that the anticipated consequences are such that Government action is unnecessary.

In general. the need for any kind of Government action arises whenever an unacceptable condition occurs or is projected to occur in the material flow pattern. As envisioned in this framework, this condition will be signalled when a computed index of scarcity exceeds a prescribed level. The index of scarcity, as shown in figure 111-5, could take many forms. It might be a price threshold: if the projected price change is too high, for example, remedial act ion might be required. Another measure, particularly useful for long-range materials policy analysis, might be the "time-to-exhaustion" of the materials, In practice, a set of different, unique indices (trigger points) would be adopted for each critical material, reflecting the existing pattern of flow and the potential disturbances that might interrupt that pattern.

Indicative of the more complex forms of policy analyses to which the improved capab i 1 i t ies might be applied, figure III-6 shows how it might be conceptually structured to assist policy makers in analyzing the potential of material substitution to relieve shortage conditions. The key points of initial impact in the materials cycle are the material availability y and production functions. As shown in figure III–6, materials A–E represent the candidates for substitution. The framework could evaluate their impacts on other materials (F–I) utilizing the demand function as the transfer mechanism. The system would show changes in demand for each material (F–I) caused by each candidate substitute material (A–E): it would then evaluate the changes throughout the other materials cycles (F–I). This kind of information would enable the substitution analyst to determine which candidate material has the greatest potential for relieving the shortage. Of course, a host of factors not explicitly shown in the figure also affect the analysis and need to be factored in. e.g., the environ mental impact of each substitute would have to be evaluated. Other substitution considerations are discussed in appendix A,

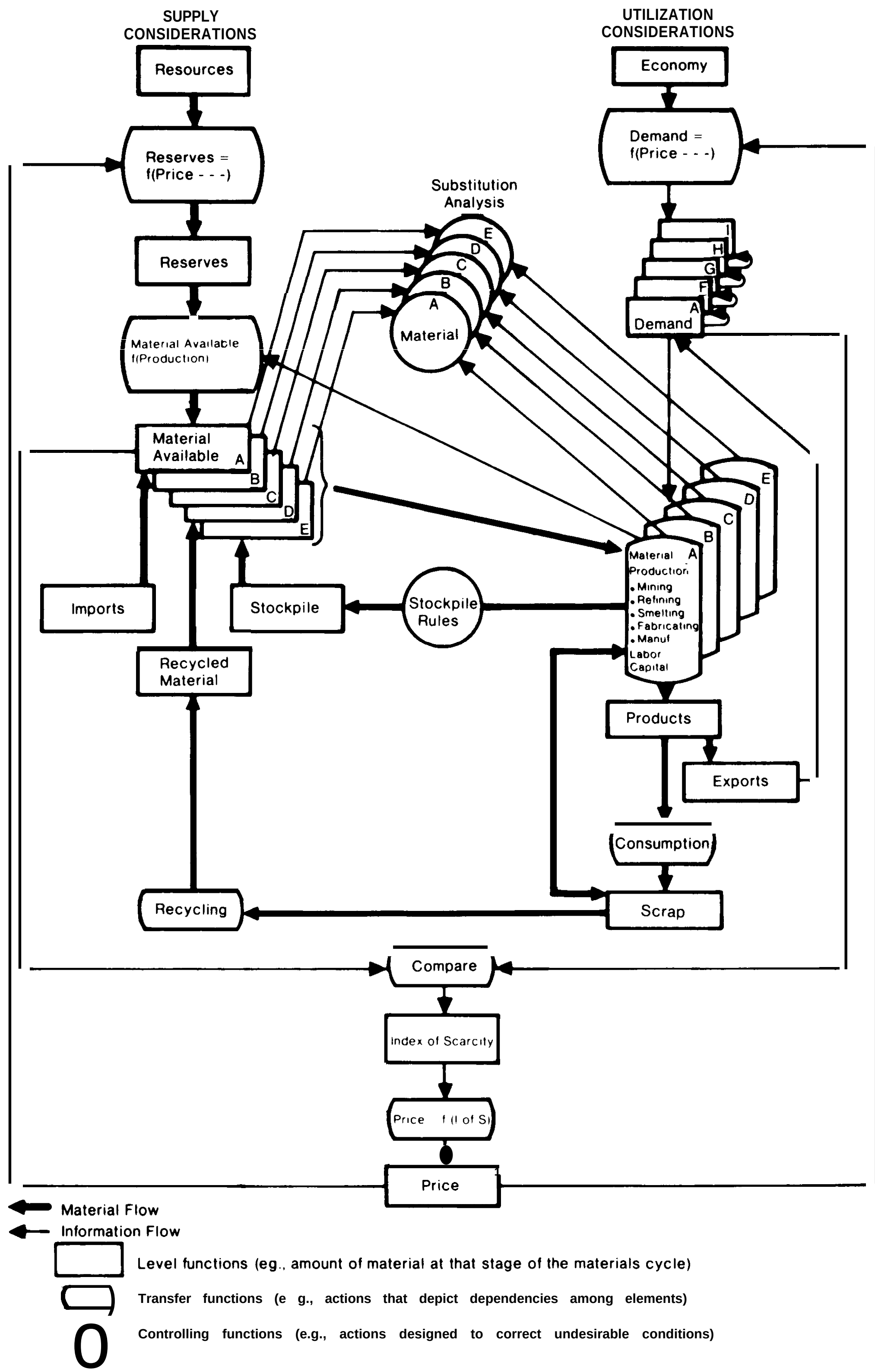
4. Evolution of Capabilities

It is important to recognize that it is not necessary to incorporate all of the individual functional requirements discussed in section F into the conceptual framework at one time. Rather, the framework could evolve, first incorporating the level functions and transfer functions that are best understood, and later adding other functions whose developments will take more time to perfect.

Considering (1) their relative importance in depicting materials flow, and (2) the state-of-the-art for obtaining the relevant data and defining the associated transfer functions, the assessment suggests that the following basic functional capabilities ought to be initially implemented:

- Monitor and project resource inventories,
- Monitor and project reserves inventories,
- Monitor and project industrial stocks,

Figure ill-6.-Basic Informational Framework Applied to Materials Substitution



- Monitor and project stockpiles (strategic and economic),
- Monitor and project imports,
- Monitor and project recycled materials.
- Forecast total supply,
- Monitor and project materials produced and production capacity,
- Monitor and project material consumed in end products,
- Monitor and project exports,
- Forecast total demand, and
- Forecast price impact on supply and demand.

If implemented within the integrated framework described here, these functions could provide substantial capability to assist policy makers in addressing such questions as:

- Will a shortage in a particular critical material occur, and when ?
- Where will the impact be felt most severely ?
- How might affected industries act to ease the resulting economic distortions?
- What other measures (conservation, stockpiling, expanding productive capacity) might be adopted?

The basic functions are all deemed to be implementable within the current state-of-the-art. Acquiring all the necessary information will present problems, but much of it appears to be available, at least for certain materials, as indicated in figures III–7 and III–8 covering aluminum. (In this connection, it should be noted that the assessment did not attempt to select the specific materials that might be included within the conceptual framework. The number of materials covered might be of the order of 50. For comparison, the President's Council on International Economic Policy identified 19 materials as critical.)

The set of functional capabilities that might be added later to the basic set could enable policy makers to address more complex problems than would be possible with the basic set. The supplemental set might provide. for example. the capability for a more accurate and comprehensive impact assessment of policy alternatives. Thus, policy makers could address regional analysis, worldwide materials supply/use assessment. comprehensive intercommodity substitution analysis, and the implications of such operational considerations as transportation requirements. availability y of capital, and availability of trained manpower. Also, policy makers using a supplemental set of functional capabilities might be able to assess the potential impacts and restraints of national policies related to employment. protection of the environment, and conservation of energy.

The assessment identified the following functions which could be added to the basic set:

- Monitor and project foreign supply and utilization. This function would supplement the basic functions that monitor and project inventory of domestic resources/reserves and imports/exports. It would seek to acquire and utilize data on foreign resources and reserves and on trade between foreign countries to a greater extent in the equilibrium analyses.
- Monitor and project environmental impact and energy use. This function would acquire the necessary data on energy use throughout the materials cycle and would show the relationships and trade-offs among production, price, environmental impact, and conservation, among other variables.
- Project recycling potential. This function would supplement the basic function covering recycled material. Whereas the basic function covers the established recovery industry. this function accounts for the potential of additional recovery using advanced technologies not currently used. It also could be used to evaluate the effectiveness of incentives to encourage such advanced technologies.

Figure III-7.—Aluminum Information Sources for Supply Functions

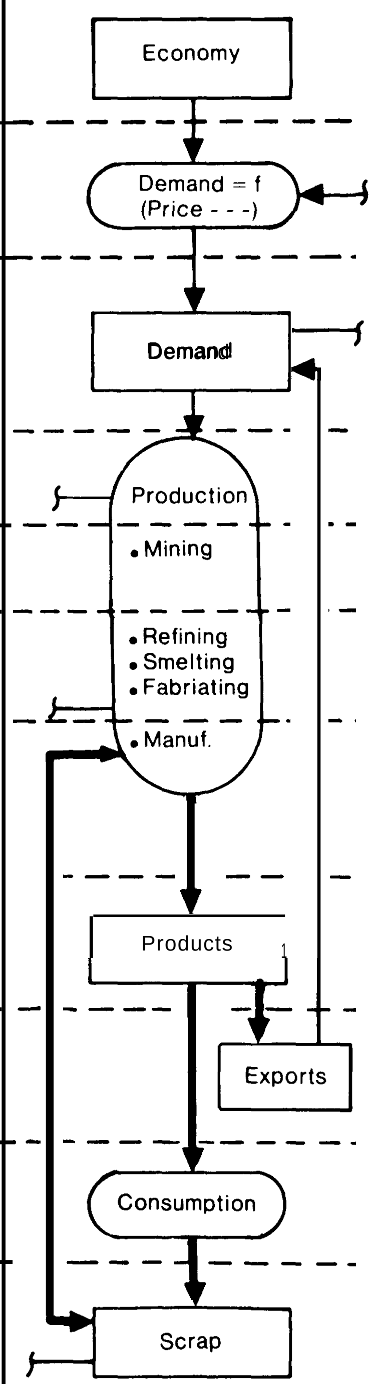
Supply	Information	Source: Government	Source: Private
Resources	Resource and Site Characteristics	GS DOA	
Reserves = f(Price - - -)	Reserves Classification	GS BOM	
Reserves	Quantity of Reserves	GS BOM	Industry
Material Available = f (Production)	Quantity Mined and Capacity of Mining	BOM	
Material Available	Quantity of Material Available (Annual-Short and Long Term)	DOA DOM OMPD	
Imports Stockpile	Inventory of Stocks	BOM GSA	Industry Aluminum Assoc.
	Quantity Imported	Customs Census	Aluminum Assoc.
Recycled Material	Quantity of Material from Scrap	BOM	Industry Aluminum Assoc. Aluminum Recycling Assoc.
Recycling	Recycling Process		Industry

Material Flow
Information Flow

Figure III-8.—Aluminum Information Sources for Utilization Functions

Information	Source: Government	Source: Private
State of U.S. Economy (GNP, and Sectors)	**DOC** (Sic)	
Price Impact on Demand	DOC FEA EPA	
Quantity of Material Demand, Annual	DOC (Short term)	Aluminum Assoc. Industry
Mining Processes Quantities Mixed	BOM	Industry
Primary Material Production and Capacity	DIBA Bur. of Census	Aluminum Assoc. Industry
Manufacturing Processes, Production and Capacity	Bur. of Census DIBA	Industry
Annual Quantity of Material in Each Product	DOC	Industry
Material Exported, Annual	Bur. of Census	Aluminum Assoc. Industry
Useful Life of Products		Industry
Quantity of Material In Discarded Products		Industry

UTILIZATION



~ Material Flow

+- Information Flow

- Monitor research and development. This function would factor research and development information into the supply/utilization analysis, thereby improving its accuracy and realism. The tie-in between the R&D information systems and the economics-oriented system would also be useful in indicating objectives for improved technology. Thus, if the overall system indicated a materials shortage in say, nickel, R&D opportunities and programs could be evaluated in light of the seriousness of the threat. Data on results of current research, along with data on scientific manpower, such as availability and current research interests, would also aid in the formulation of R&D programs to address identified problem areas, The extended function might also provide a basis for better judging as to whether or not R&D could affect a perceived shortage within a given lead time.
- Determine substitutability. This function would enable analysts to consider more completely the effects of substitution of one material for another, Another possibility is to combine this function with an information system covering physical and chemical materials properties to achieve a computer-assisted materials selection system, This would enable planners and users to evaluate the merits of using one material in place of another, taking into account economic conditions as well as technical properties. As detailed in appendix A, it appears that much of the information needed for such a system is identical with that needed for a general purpose materials planning system.
- Monitor availability of investment capital, transportation, and trained labor. These factors all impact long-range supply. Elaborating the basic system to incorporate their effects increases the overall accuracy of solutions and would enable policy makers to address more detailed and more subtle aspects of materials flow.

H. SUMMARY

In establishing whether a need exists for significantly improved materials information capabilities, objective quantitative criteria are preferred. Unfortunately, this is not possible. Like other problems in the public policy area, analysis of information systems is hampered by the absence of a recognized, theoretical framework covering the economic value of information. In theory, to the extent that information provided by a materials information system reduces uncertainty, it contributes to more risk-free and, thus, more effective decisionmaking. In practice, however, the decisionmaking process, even in a relatively straightforward industrial situation, involves so many other factors blurring the contribution of the information element that attempts to quantify the value of information are rarely conclusive. They become even more clouded when attempted in the Government policymaking area.

In the absence of purely objective standards, this assessment drew on the experience of informed specialists, as expressed in reports of materials study groups, congressional activities, and a series of interviews with materials executives and managers. The overall conclusion to be drawn from this body of experience is that current systems are not adequate and that new improved capabilities would enable materials managers, particularly in Government, to do a better job,

The assessment also pointed to two other considerations. First, it emphasized the indispensable need to better interrelate the various factors bearing on materials supply and demand. Policy makers need to know where relevant data exists. They need to be able to compare the data on a consistent basis, regardless of the data sources, and they need to be able to merge data from different data bases for comprehensive materials-flow analyses. Second, the study confirmed the view that to achieve the needed. improved capabilities, a systematic view of the materials information problem is required. Individual information systems that currently deal with limited aspects of the overall materials problem must be seen in perspective as sub-systems, and improvements to each must be undertaken within the context of a coordi - nated, overall, plan.

The assessment developed a conceptual information framework that might serve as the basis for such improvements.

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Chapter IV

POTENTIAL OF EXISTING FEDERAL MATERIALS INFORMATION SYSTEMS TO SUPPORT THE INTEGRATED CAPABILITIES

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Review of a limited set of materials information systems currently in use by Federal agencies indicates that they provide a reasonably strong base for developing the integrated capabilities. Many of the basic functions are already being implemented or are in development, and much of the required data is being generated and collected.

However, since the existing systems were developed by different agencies, for different purposes, and at different times, integrating them to achieve the improved capabilities requires:

- **Improving the completeness, currency, and accuracy of their data bases;**
- **Improving the access to them and the ability to interrelate them by adopting more uniform usage of terms and developing procedures for ensuring data security; and**
- **Improving their capabilities for analyzing the data and presenting results to decisionmakers in meaningful formats.**

A. INTRODUCTION

Many of the Government agencies involved in materials policymaking operate materials information systems comprising people, procedures, facilities, and data in a variety of forms, Some are predominantly manual; some make substantial use of automation. All have evolved over man y years as institutions and all have been assigned varying responsibilities for different classes of materials. They all gather and analyze relevant data to monitor conditions in particular materials sectors and measure the effectiveness of Government policies thereto. Most systems publish their statistics on supply or utilization as a service to industries and the public, Many of the systems have been very stable. For others, missions and techniques have changed over the years as new needs and priorities arose, and these have been augmented to meet special, time-critical requirements.

This segment of the assessment examined a selected set of these systems to find how they might support the integrated capabilities. A collateral aim was to understand the operational problems these systems encountered so that their experience could be factored into the consideration of how the integrated capabilities might be implemented. It should be emphasized that, except for those cases where the systems specifically matched the integrated capabilities, no attempt was made to evaluate how well the current systems are accomplishing the jobs for which they were built.

Personal interviews, using a formalized questionnaire, were conducted with personnel of 10 Federal agencies. Additionally, the assessment reviewed descriptions of materials information systems used by Congress, four other Federal executive agencies, and several State governments. In all, over 60 interviews were conducted with managers and users of materials information systems.

B. CONGRESSIONAL INFORMATION SYSTEMS

Congress obtains information to support materials policymaking from three principal sources: (1) the Federal and State executive systems; (2) the private sector, including industry, trade associations. academic institutions, lobby groups, and the general public; and (3) its own information systems. The legislative systems are oriented to the special kinds of information Congressmen and their staffs require. These cover:

- Fiscal-budgetary information, such as:
  - —New budget requests,
  - —Past budget and expenditure data,
  - —Funding by line item entry and special subject category,
  - —Long-range budget projections;
- Program evaluation data, such as:
  - —"Hard" data (inventory and economic data),
  - —"Soft" data (numbers of people served by programs, social impact);
- Program oversight data, such as:
  - —Authorizing statutes,
  - —Relevant appropriations (initial and follow-on),
  - —Executive branch implementation actions;
- Data on status of legislation, such as:
  - —Pending bills,
  - —Expiring laws,
  - —Historical data; and
- Research information, principally scientific and technical information.

The congressional agencies that provide this information include:

- Congressional committees and administrative offices,
- Congressional Research Service (Library of Congress),
- National Referral Center (Library of Congress),
- Congressional Budget Office,
- General Accounting Office, and
- Office of Technology Assessment.

Table IV-1 lists some of the information sources.

In calling on all these agencies for information, Congressmen and their staffs correlate and reconcile discrepancies in the different inputs and integrate the mass of data—a major task. Two centralized legislative information systems have been established. The Bill Status

Table IV-1.—Congressional Agencies Serving Legislative Information Needs

Information Source	Type of Information				
	Fiscal-Budgetary Information	Program Evaluation Data	Program Oversight Data	Legislation	Research Information
U.S. Congress, committees and administration		x	X	X	
Congressional Research Service		x	X	X	X
National Referral Center					X
Congressional Budget Office	X	x	X		
General Accounting Office		x	x		
Office of Technology Assessment		x	X	X	X
Executive sector input	X	x	X		X
Public sector input		x			X

System (Aquarius) provides legislative history, tracking, and statistical data and printed status reports. Indexing is done by subject matter (metals, forestry, aluminum, resources, timber, etc.), sponsor or co-sponsor committee, date, and number. The Legislative Information System (Scorpio) provides a bill digest, major issues, material, referrals to organizations related to technology and the sciences, and printed reports. These systems provide a searching and retrieval capability based on the subject matter indexes or more specific parameters. Their use does not replace the analysis of documents. but they do provide access to legislation, bibliographies, reports, and references to pertinent organizations. They can alleviate the problem of receiving too much information, since searching can be refined to reduce the number of relevant references.

Still other information services are routinely provided by the Library of Congress. The Senior Specialist Division of the Congressional Research Service provides information in the form of analyses, interpretive studies, projections, chronologies, facts, and special bibliographies. The National Referral Center (NRC) also provides research information in terms of referrals to organizations and individuals who can answer specific questions in scientific and technical fields. NRC uses a subject-indexed data base containing profiles of 9,000 organizations. The Center's referral specialists provide names, addresses, telephone numbers, and their areas of expertise in response to queries.

These legislative information systems do not have sufficient analytical or integrating capability of the kind needed to provide forecasts of the possible effects of policy decisions on the economy, For this, Congress must rely on the executive branch and the private sector. Thus, while Congress can improve its own systems, its most effective avenue for obtaining better policy planning information appears to be to strengthen the existing Federal executive systems and to establish procedures guaranteeing access to them.

C. EXECUTIVE MATERIALS INFORMATION SYSTEMS

The Federal agencies covered in this review are listed in table IV-2. Additional contacts were also made with agencies of some 13 States; of these, data bases maintained by Alaska and Illinois were pertinent to the review and were included.[1]

In questioning managers and users of these materials information systems, the survey focused on:

- Data bases;
- Information management systems, i.e., the techniques which build and maintain the data bases, and retrieve, sort, and produce reports: and
- Mathematical/analytical models and tools used for interrelating supply and demand factors to arrive at forecasts.

1. Data Bases and Information Management Systems

Table IV–3 summarizes some of the institutional characteristics of the 23 data bases and the associated information management systems that were examined. The table shows the automated information management system, if any, which the data base supports; the agency responsible for operating the systems; the geographic location of the data base; and the purpose of the system. Except for the data bases sponsored by Alaska and Illinois, and a few cases in which States support SRS and EPA data bases, virtually all funding for these systems is borne by the Federal Government. (In the case of the DOD Information Analysis Centers, user fees provide for a substantial portion of the costs; however, most users are DOD contractors and these costs are ultimately borne by the Government,)

The review indicated a trend away from specific programs to support special data bases towards generalized data management systems which support multiple data bases more easily and with better response time for special requests. These data management systems also support proprietary files and limit access by nonqualified users.

Table IV–4 summarizes the materials information provided by the selected data bases. The sponsoring Federal agencies are the main data base users, primarily due to limited access to proprietary data maintained at the company/site level. Data from some bases, like CRIB and TIMLUC, are currently restricted to Federal and State employees, but this restriction may change under the Freedom of Information Act. When the proprietary data is summarized to a sufficient level of aggregation, it is considered open to other agencies and the public. However, provisions and facilities for public access are not available on a regular basis. United States Geological Survey has a study to make the CRIB data base available to users via CRT terminals at Menlo Park, Calif., or Denver, Colo.

As shown in Table IV–4, there is a concentration of effort with apparent redundancy in the energy fuels area, USGS, BOM, FEA, FPC, ERDA, and the Bureau of Census are all involved in data collection either on a voluntary or a mandatory basis. Most of the data bases indicated in the table suffer from a lack of adequate international data. Many countries do not collect the data or are unwilling to make it available. The State Department's CERP and USDA's Foreign Agricultural Service account for the most of the international data.

Tables IV–5 and IV–6 list some of the data processing characteristics of the data bases. As

[1] Contacts with the others (Arkansas, Arizona, California. Colorado, Georgia, Iowa, Maryland, Montana, New Mexico, Texas, and Utah) indicated that their resource-oriented information systems were developed for soil, land use, and water resources rather than for materials, per se.

Table IV-2.—Agency Personnel Interviewed During Survey

Agency	Title
Department of Agriculture	Analyst, Office of the Secretary
Economic Research Service (ERS)	Director
Forest Service (FS)	Administrator of Service
Statistical Reporting Service (SRS)	Chief Research Division ADP Technical Personnel
Department of Commerce	
Bureau of Census	Director
Bureau of Economic Analysis (BEA)	Analyst
Domestic and international Business Administration (DIVA)	Associate Director, ADP
National Bureau of Standards (NBS)	Chief
department of Defense information Analysis Center (DOD/IAC)	Staff Specialist
department of the Interior	
Bureau of Land Management (BALM)	Chief,ADP Analyst
Bureau of Mines (BOM)	Department Manager Program Coordinator Chief of Statistics Branch Commodity Specialist
Office of Mineral Policy Development (OMPD)	Director Minerals Analyst (Mining Engineer)
U.S. Geological Survey (USGS)	Branch Chief Commodity Specialist Branch Chief
department of State	
Industrial and Strategic Materials Division	Assistant Chief
Energy Research and Development Administration (ERDA)	Assistant Director for Raw Materials
Environmental Protection Agency (EPA)	Project Director
Federal Energy Administration (FEA)	Director Chief,~ADP Project Manager
Federal Power Commission (FPC)	Director, Plans and Program
General Services Administration (GSA)	Staff Analyst

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Table IV-3.—Institutional Characteristics of Selected Data Bases and Associated Information Management Systems

Data Base	Information Management System	Agency	Location*	Purpose
CRIB	GYPSY	USGS	R	Organize, analyze, summarize mineral resource data
NCDB	GYPSY	USGS	R	Report world coal resource data
FAS	DMS II	BOM	D	Maintain petroleum, coal, and natural gas statistics
MAS	DMS II	BOM	D	Provide mineral resource and reserve data for materials policymaking
CDB	DMS II	BOM	D	Maintain mineral production and capacity support MAS
PD Inventory	—	BLM	D	Select field plots for sampling, predict field data, provide timber inventory and data for modeling
Minerals	—	BLM	D	Manage mineral resources in planning and utilization systems
Census	—	Bur. of Census	S	Develop and produce reports, and support other agencies
TIMLUC	INFORM	FS	FC	Keep inventory of Federal timber for long-range planning
SRS	—	SRS	W	Estimate agricultural commodities
Stockpile	—	GSA	W	Maintain data on stockpiled strategic materials under GSA control
Fuels	—	FEA	W	Moniter and regulate energy industry
Sec. Index	FEILS	FEA	W	Maintain directory of energy data and information sources
Environment	—	EPA	RA	Inventory point and area sources and amounts of emissions
Air Quality	—	EPA	RA	Maintain nationwide air quality data
Water Quality	—	EPA	W	Maintain nationwide water quality data
Uranium	ORCHIS	ERDA	G	Maintain uranium statistics to project U.S. supply and demand
World Energy	ORCHIS	ERDA	G	Survey energy reserves in all countries
RIS	RIS	FPC	W	Support decisionmaking, regulatory activities, productivity, and cost
MCIC		DoD/IAC	C	Provide technical advice and assistance to DOD agencies and contractors
CERP	CERP	Dept. of State	W	Facilitate retrieval of foreign economic data
Basic Coal	Coal Data Sys.	Illinois	U	Provide energy data for survey research
Gas/Oil	—	Alaska	A	Maintain gas and oil well statistics for State production tax revenue forecasting

*Location: A—Anchorage, AL C—Columbus, OH D—Denver, CO FC—Fort Collins, CO G—Germantown, MD R—Reston, VA RA—Raleigh/Durham, NC S—Suitland, MD U—Urbana, IL W—Washington, DC

Table IV-4_Content Characteristics of Selected Data Bases

Data Base	Agency	User*	Materials Covered: Nonfuel Minerals	Materials Covered: Mineral Fuels	Materials Covered: Forest Products	Typasof Data	Number of Records	Functional Areas: Resources	Reserves	Production	Price	Consumption	Imports	Exports	Waste Products	Stockpiles	Recycling	Transportation	Energy Req.	Capital Investment	Labor	Other**	Domestic	International
CAIB	USGS	All	X	X		Minerals & coal location:geology; prod.; reserves, resources eat.	50,000 in 1975 150,000 by 1977	X	X	X												1	X	X
NCDB	uSGS	All		X		Coal resource est. & reliability; geology: depletion rate; chem. analysis	5,000,000 by 1980	X	X	X												1	X	X
FAS	BOM	All		X		Coal prod., reserves, resource est:oil, oil shale, &gas prod:oil imports:chem. anal.	1,000,000 in 1975	X	X	X	X		X	X	X	X			X				X	
MAS	BOM	F, S, I	X			Minerals (alum., gold, tin, nickel)resource est.; extraction volume &costs, transporta tion profile; capital & operating costs	1,000,000 in 1975† 35,000,000 by 1980†	X	X	X								X		X			X	
CDB	BOM	F	X	X		Minerals prod. & prod. capacity: secondary recovery		X	X	X	X	X	X	X	X	X	X						X	X
PD Inventory	BLM	F			X	Field sample profiles; timber resource est.	420,000 in 1975	X	X														X	
Minerals	ELM	F. S, I	X	X		U.S. public land reserves & resources eat.; leasing; map coordinates	797,000 by 1982	X	X	X													X	X
Census	Bur of	F, T, U	X	X	X	Prod., recycling, import, export statistics				X	X	X	X	X		X	X	X					X	
TIMLUC	FS	F, S, I, U			X	Field samples profiles; timber resource est.; aerial photo descriptions	70,000 by 1980	X	X	X	X	X	X	X				X					X	
SRS	SRS	F, S	X			Field sample profiles; prod. by crop	20-30,000,000 in future††	X		X		X	X	X		X							X	X
Stockpile	GSA	F	X			Quantites by location; chem. analysis	7,000 in 1974	X	X				X			X							X	
Fuels	FEA	F		X		Coal & oil statistics			X	X	X	X	X	X					X				X	X
Sec. Index	FEA	F		X																		2	X	
Environment	EPA	F, S	X	X	X	Area prod. & prod. capacity; consumption; waste prod.; energy req., esp. for coal	70,000 in 1974			X	X	X			X		X		X				X	
Air Quality	EPA	F, S		X		Air pollution measurements, esp. for cod									X								X	
Water Quality	EPA	F, S		X		Water pollution measurements,esp. for oil									X								X	
Uranium	ERDA	F	X	X		Uranium resource estimates		X	X	X													X	
World Energy	ERDA	F, 1, T	X	X					X						X								X	X
RIS	FPC	F		X	X	Reserves; prod. & prod. capacity; price & cost; consumption; capital investment	1,000,000 in 1975 5,000,000 in future		X	X	X								X				X	X
	DOD IAC	F	X			R&D abstracts;term index; bibliographic details	100,000 in 1975			X	X		X	X				X		X	X	1	X	
CERP	Dept. of state	AAI	X	X	X			X	X	X	X	X	X	X		X	X		X	X				X
Basic Coal	Illinois	S		X		Ill. reserves & resources est.; prod.; chem. analysis	35,000 in 1976 250,000 by 1981	X	X	X												1	X	
Gas/oil	Akaska	S, 1, U		X					X	X												3	X	

* Users: F - Federal; S - State; I - Industry; T - Trade association; U - University

** Other: 1 - Physical and chemical properties; 2 - Energy data sources; 3 - Drilling and tax revenues

† Characters per mineral

†† 400 to 500 crops for 5 to 10 year period and 25 geographic areas

Table IV-5.—Data Collection and Handling Characteristics of Selected Data Bases

Data Base	Data Sources								Data Collection Methods									Update Frequency						Data Base Form				Storage Media			
	Primary			Secondary																											
	Government	Industry	Other	Federal	State	Trade Assoc.	University	International	Voluntary Questionnaire	Mandatory Questionnaire	Remote Sensing	Data Exchange	Published Reports	Voluntary Industry Report	Mandatory Industry Report	Data Transfer	Aerial Photo.	Annually	Weekly	Quarterly	Daily	Monthly	Ad Hoc	Manual	Automated	Numeric	Text	Disk	Tape	Card	Microfilm
RIB	X	X	X	X	X			X					X	X									X		X	X	X		X		
ICDB	X	X	X	X	X			X	X					X									X		X	X	X		X		
AS	X	X		X	X		X	X	X				X	X				X	X	X	X	X	X		X	X	X	X	X	X	
IAS	X	X	X	X	X	X			X				X	X									X		X	X	X	X	X		
DB	X	X		X		X		X	X				X	X				X	X	X	X	X		X	X	X	X	X	X		
D nventory	X	X	X						X		X						X	X							X	X			X		
linerals	X		X	X	X		X										X	X							X	X		X			
		X		X	X				X	X		X	X	X	X							X			X	X		X	X		X
'IMLUC	X		X	X	X			X	X								X				X		X		X	X		X	X		
RS	X	X						X	X									X				X			X	X		X	X		
tockpile	X			X												X				X					X	X			X		
uels		X		X											X			X	X	X		X			X			X			
ec. Index		X		X					X													X	X		X	X	X	X			
nviron-ment	X		X	X					X	X			X	X	X	X							X		X	X	X	X	X	X	
ir Quality	X			X	X						X	X		X						X					X			X	X		
Vater Quality	X			X	X				X	X	X	X											X	X	X			X	X		
Iranium	X	X								X		X	X	X	X	X		X						X	X	X		X			
Vorld Energy		X						X								X							X	X	X	X		X			
IIS	X			X					X							X		X	X	X		X			X	X	X	X			
ICIC		X		X		X			X	X			X	X		X		X						X	X	X			X		
ERP			X					X	X				X	X		X							X	X	X	X		X	X	X	
asic Coal			X					X					X	X									X		X			X			
ias/Oil		X													X							X			X				X		

Table IV-6.—Data Maintenance and Reporting Characteristics of Selected Data Bases and Associated Information Management Systems

Data Base	Information Management System	Location	Data Maintenance: Batch	Outline	Specialized	Generalized	Data Retrieval: Batch	Online	Teleprocessing	Query Language	Special Program	Analysis Technique: Statistical	Modeling	Simulation	Gaming	Other	Output: Printout	Tape	Card	Graphics	Tables	CRT	Turnaround Time*
CRIB	GYPSY	R	X	X		X	X	X	X	X		X					X	X		X	X		
NCDB	GYPSY	R	X	X	X	X	X	X	X	X		X					X	X		X	X	X	
FAS	DMS II	D	X	X			X	X				X	X			X	X	X		X	X		
MAS	DMS II	D	X	X			X	X	X		X	X	X			X	X			X	X	X	1
COB	DMS II	D	X	X			X	X	X		X	X	X			X	X			X	X	X	
PO Inventory	—	D	X			X	X					X	X	X		X	X	X					2
Minerals		D				X	X	X	X			X	X	X		X	X	X				X	3
Census	—	s	X	X			X	X				X					X	X		X	X		4
TIMLUC	INFORM	FC	X	X			X	X				X	X				X	X		X	X	X	3
SRS	—	w	X	X			X	X	X			X					X			X	X	X	
Stockpile	—	w	X				X	X				X	X				X						5
Fuels	—	w	X	X			X			X		X	X								X		
Sec Index	FEILS	w	X	X			X	X								X	X				X		2
Environ-												X	X			X	X	X			X		
ment	—	RA	X				X			X		X	X			X	X	X	X			X	
Air Quality	—	RA	X				X																
Water Quality	—	w	X	X			X	X	X	X	X	X	X			X	X	X	X	X	X	X	
Uranium	ORCHIS	G	X				X					X				X							
World Energy	ORCHIS	G	X	X			X	X				X				X							
RIS	RIS	w	X	X			X	X	X	X		X	X	X			X	X		X	X	X	
MCIC	—	c	X	X			X	X	X			X	X	X			X	X				X	2
CERP	CERP	w														X							
Basic Coal	Coal Data Sys	u	X			X	X				X						X						2
Gas/Oil	—	A	X				X					X	X			X	X						

*Turnaround Time 1—72 hours 2—24 hours 3—immediate (online) 4—48 hours priority, up to 1 month- normal 5-3 hours

listed in table IV–4, the primary data sources are questionnaires and surveys conducted by the agencies and reports from industry, both mandatory and voluntary. Secondary data sources are publications from other agencies. For some files (trade data from the Bureau of Census and MAS data from BOM), magnetic tapes are used to exchange computer-sensible data between data bases.

All the data bases verify the data to some extent. Most use historical trends and inspection; some use error analysis programs. The frequency of update ranges from monthly to every 10 years. Table IV-5 also lists the form of the data bases and the types of storage media employed. Table IV-6 shows that for some of the automated systems, direct-access disk files are being used and others are moving toward adopting them. These permit online file maintenance and retrieval from remote typewriter and CRT terminals. The GSA network INFONET provides online maintenance and retrieval capabilities for several agencies,

Table IV-6 also indicates the types of analysis techniques used in the information management systems. The analysis support capability, which becomes increasingly important as more complete and reliable data are gathered and maintained, includes mathematical and statistical functions. Report program generators are available, both online and through remote processing, to support particular formats and aggregations required by users. The types of output formats available from the various systems are listed in table IV-6.

2. Mathematical/Analytical Models

Although the distinctions are not clearcut, the models used in materials information systems fall into four general categories: (1) econometric regression models, (2) input/output models, (3) linear programming models, and (4) simulation models. Econometric regression models, the most widely used, are generally developed on an ad hoc basis for specific purposes, thus their strengths and weaknesses are model-specific. In contrast, input/output and linear programming models permit generalizations of their capabilities and limitations. Simulation and other specialized models are only occasionally used in forecasting/planning.

As indicative of their states of development, a survey of 39 models was conducted to determine how well they could accomplish the analytical functions for the improved capabilities. Table IV–7 lists the models surveyed, their users, the areas of application/analysis, and the functions supported by the models. In a general way, the table indicates the functional areas for which forecasting models are more developed than for others, notably in the areas of demand models and production distribution models.

a. Econometric Regression Models. The Aluminum Forecasting Model (AFM), developed by Charles River Associates of Boston, Mass., is representative of available econometric models. It is a form of regression modeling consisting of simultaneous equations fitted from historical data by means of regression techniques. It has been formulated to analyze the interaction between aluminum supply and demand and, in particular, the impact of Government actions on the price movements of aluminum ingots, For example, it can be used to analyze the effects of alternative GSA aluminum disposal policies. The model's scope and capabilities to support materials management are summarized as input and output in figure IV–I.

AFM, as well as other econometric regression models, relies heavily on extrapolation from historical trends. This inhibits consideration of dynamic changes in economic, demographic, or technological trends. Capacity installations are projected on the basis of information from the aluminum industry, but no significant technologically induced structural changes were contemplated during the model's planning horizon (1972-76), Furthermore, model performance is very sensitive to discontinuities in the required time-series inputs, Another limitation is that AFM accounts only for the market clearing mechanism for one stage of the aluminum industry (production of aluminum ingots); it does not account for price, supply, and demand patterns in other segments of the industry (in the bauxite mine segment or the final aluminum user segment), The model appears to be very rigid in that the set of equations describing the market adjustment mechanism does not apply during periods of rationing, Indeed, it is a limitation generic to econometric regression models that they are special-purpose tools and are only appropriate for a narrow range of applications,

b. Input/Output Models. The information-generating capabilities that input/output models offer to materials management are shown in the information flow summaries of Figure IV–2 for (1) CIAS (GSA's Contingency Impact Analysis System), (2) EEPPM (University of Illinois' Energy -Employment-Pollution Policy Model), (3) INFORUM (Interindustry Forecasting Model—University of Maryland), and (4) SEAS (EPA's Strategic Environmental Assessment System). The similarities and dissimilarities between input and output among these models are apparent. In general, they account for the demand side of the materials

Table IV-7.-Mathematlcal/AnaJytical Models Surveyed

Modal	Name	User	Area of Application/Analysis	Resources/ Reserves	Stockpiles	Imports/Exports	Recycling	Production, Production Capacity	Consumption	Demand	Price Impact on Supply/ Demand
				Functional Areas							
APM	Aluminum Forecasting Model	GSA	Effects of GSA aluminum disposal policies on the price movements of aluminum ingots			X	X	X	X	X	X
BEAFPM	Bureau of Economic Analysis Fiscal Policy Model	DOC	GNP forecasting								
BEAIO	Bureau of Economic Analysis Input Output Model	DOC	Interindustry forecasting							X	
BEAQM	Bureau of Economic Analysis Quarterly Model	DOC	GNP forecasting								
BESOM	Brookhaven Energy System Optimization Model	EROA	Alternative production and distribution techniques, policies on energy materials					X			
CACM	Copper-Aluminum Competition Model	...	Dynamics of competition between aluminum and copper			X	X	X	X	X	X
CAIDM	Copper-Aluminum Industrial Dynamics Model	...	Dynamics Of competition between aluminum and copper					X			
CIAS	Contingency Impact Analysis System	GSA	Materials demand forecas ting							X	
CMIDM	Copper Market Industrial Dynamics MUM	...	Dynamics of copper market fluctuations					X			
CPCM	Commodity Production Cycles Model		Dynamics of commodity production cycles					X		X	
CPPM	Cost-Price Pressure Model	DOC	Interindustry impact assessment of changes in tha prices, productivity, profits, materials, or labor costs of an industry								
DEMOS	Demographic Economic Modeling System	...	Demographic and economic forecasting	X						X	
DESM	Dynamic Energy System Model	...	Dynamics of interfuel competition	X					X	X	
ONRUM	Dynamic Natural Resource Utilization Model	...	Dynamics of natural resource utilization							X	
EEWM	Energy-Employment Pollution Policy Model	..	Energy materials demand, employment levels, and pollution residuals forecasting								
EETM	Economic-Environmental Tradeoff Model	..	Trade-offs between economic growth and environmental quality								
EFRM	Energy Facilities and Resources Model	...	Production and distribution facilities for energy materials					X			
EMuS	Energy Model for the United States	...	Demand forecasting for energy materials							X	
EQM	Energy Quality Model	ERDA	Response of fuels supply, demand, and prices to postulated e ir quality requirements					X			
FREPAS	Forest Range Environmental Production Analytical Sys.	USDA	Alternative plans for the management and protection of range resources					X			
GIOM	Generalized Input/Output Model	--	Interindustry impact assessment of new energy technologies							X	
INFORUM	Interindustry Forecasting Model-University of Maryland	EPA	Interindustry forecasting			X				X	
MANERGY	Energy Management Modal for the United States	..	Effects of resource and fuel alternatives, environmental controls, and technological advances					X		X	
MEM	Metal Endowment Model	..	Estimation of metal - W from geophysical data	X							
MRIO	Multi-Regional Input/Output Model	DOT	Regional interindustry forecasting							X	
NIRAP	National Interregional Agricultural Projection System	USOA	Demand and supply projections on agricultural commodities					X			
NSEM	National Socio-Economic Model	...	Dynamics of economic fluctuations, growth, and environmental/resource restraints								
PIES	Project Independence Evaluation System	ERDA	Effect of fuel prices, potential of fuel substitutions, and technological constraints inhibiting energy materials supplies					X		X	
QMCWEM	Queen Mary College World Energy Model	...	International energy production and distribution system							X	X
READY	Attack Simulation and Damage Assessment Model	GSA	Attack simulation and damage assessment								
RFFM	Resources for the Future Model	EPA	Material resources demand and pollution residuals forecasting							X	
ROPE	Runout Production Evaluation Model	DOC	Early post-attack capabilities of US. economy								
SAM	Shortage Allocation Model	OOC	Interindustry impacts of commodity shortage								
SEAS	Strategic Environmental Assessment System	EPA	Material resources, demand, required reserves, and pollution residuals forecasting	X		X	X	X	X	X	X
TPECM	Tax Policy and Energy Conservation Model	EPA	Effect of tax policies on the demand and supply of energy materials								
WAIF	Wharton Annual and industry Forecasting Model	---	GNP and interindustry forecasting								
WIM	World Industry Model	---	International material resources demands and associated depletion forecasting and effects of consumption on worldwide environmental quality								
WORLD3	Limits to Growth Model	.-	nam worldwide econom and demographic growth under environmentat and material resource constraints	X					X		
WRIO	World Regional Input/Output Model	...	Worldwide industry forecasting								

economic system, with the supply side treated in a rudimentary fashion. The basic input for each model is a set of fundamental demographic and macroeconomic projections. The lists of output, however, reveal the differences due to the number of industries into which the economy is divided by the various models (86 for CIAS, 185 for INFORUM, 367 for EEPPM), the number of material groups for which requirements are computed on the basis of industry output (9 l material groups for CIAS, 23 material groups for SEAS), and the extent of further operations on the output, such as computation of employment requirements, capital requirements, and pollution residuals.

Figure IV–1. Econometric Regression Model Information Flow Summary

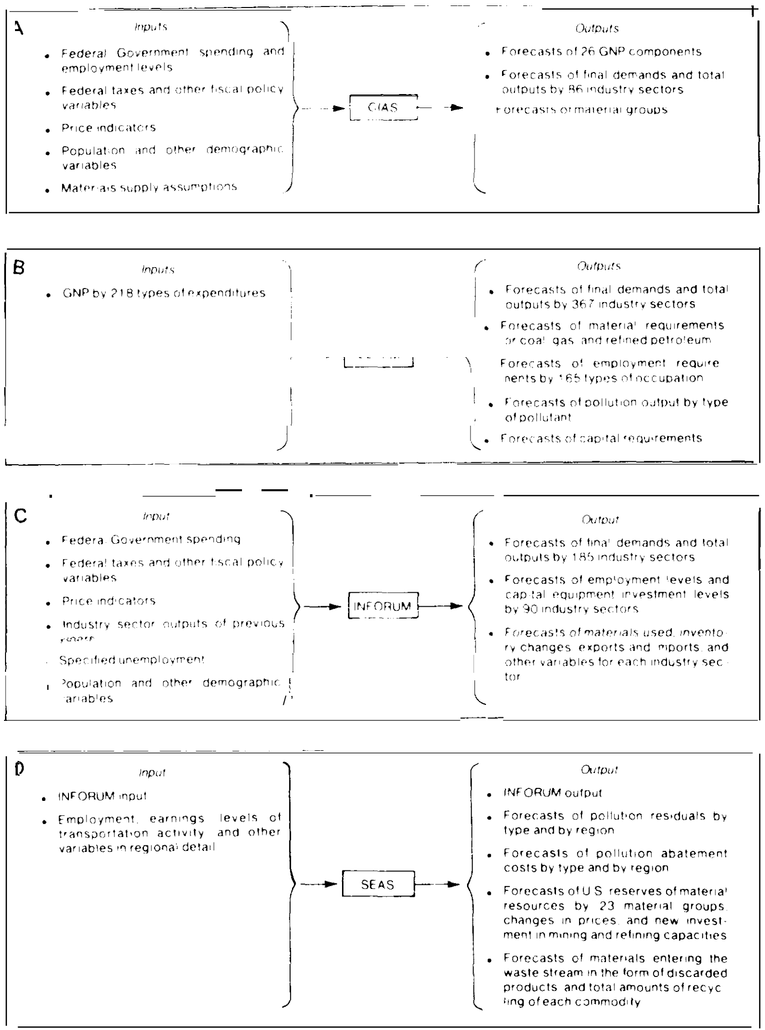
Inputs

- Unit costs of bauxite production factors
- Unit costs of aluminum ingot production factors
- Net GSA aluminum sales
- Aluminum production capacities by world areas
- U S. Disposable income and other macroeconomic indicators
- Exchange rates and other international trade indicators

outputs

- U.S. aluminum ingot shipments by utilization categories
- Aluminum scrap recovery by world areas
- Prices of aluminum ingots and aluminum scrap
- Wage Indices and other national and international indicators for the aluminum industry

Figure IV-2. Input/Output Model Information Flow Summaries

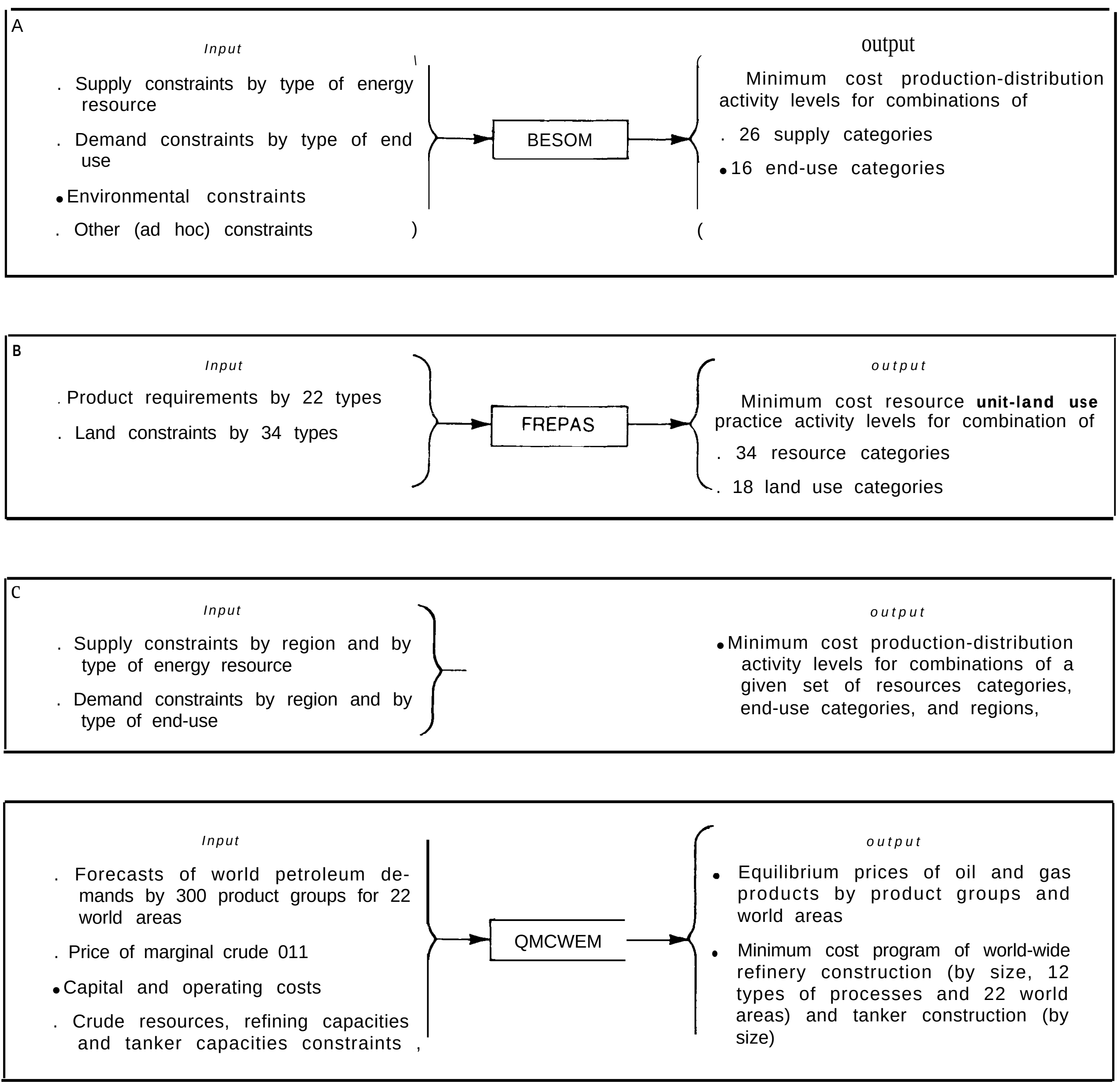


An input/output model typically does not offer the richness in detail of an econometric regression model such as AFM for a particular industry or application, but it does offer an integrated framework for the analysis of interactions among the various industries of the economy and a wide range of applications. The basic capability of such a model is to compute the total output required from each industrial sector of the economy to satisfy a given set of final demands for the products (goods and services) of each sector. In doing so, the input/output computations take into account both the first and second order effects of a change in the demand for a product on the output requirements of all industries. Thus, a change in the demand for autos will have an impact not only on the output required by the auto industry, but also on the output required by the steel industry and all other industries supplying input to the auto industry.

Although input/output models are basically a tool for macroeconomic analysis, their importance for environmental and resource policy is that they can be modified or extended (by using additional matrices of appropriately defined coefficients) to compute pollution residuals and material resource requirements for a given level of economic activity. However, as noted, only the demand side of the economy is considered, although SEAS has been developed to the point where certain feedback effects between supply and demand have been taken into account. It also must be pointed out that, while it is easy to extend the analytical input/output framework to incorporate both materials residuals and material resources, it requires a considerable amount of time and effort to develop the required data base, with the data collection and reduction requirements becoming more severe as the level of disaggregation of either industry sectors or material groups increases.

c. Linear Programming **Models.** The capabilities of linear programming models to format materials production and distribution is illustrated in the information flow summaries of figure IV-3 for four such models: (1) BESOM (Brookhaven's Energy System Optimization Model), (2) FREPAS (USDA Forest Range Environmental Production Analytical System), (3) PIES (FEA's Project Independence Evaluation System), and (4) QMCWEM (Queen Mary

Figure IV-3. Linear Programming Model Information Flow Summary



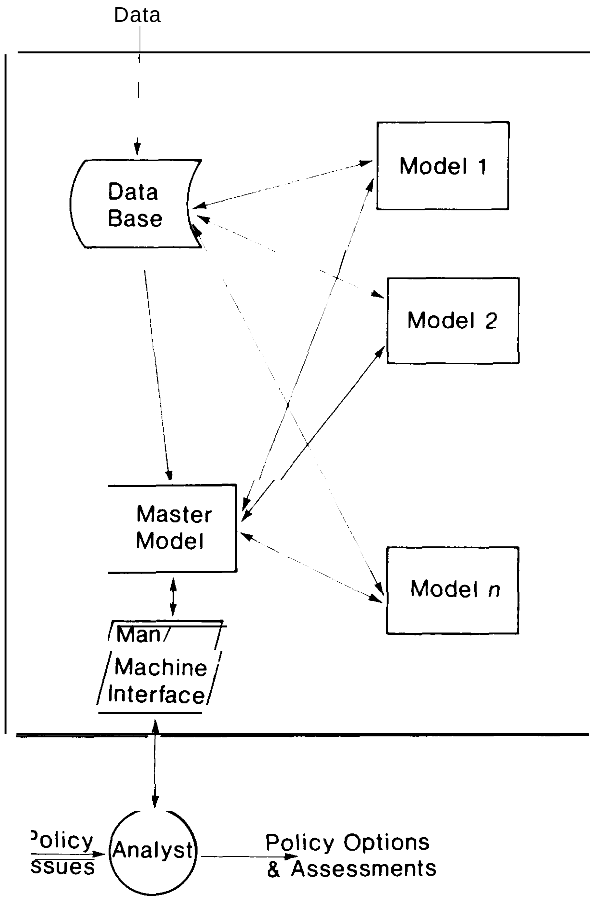
College World Energy Model). In contrast to the input/output models' rudimentary treatment of the supply side of the economy, linear programming models provide a detailed treatment. The supply structure is the web of extraction, processing, conversion, and transportation activities required to make materials actually available for use by industry and the final consumer, These activities can be represented conceptually in the form of a network and, for the case of several materials measurable in the same physical units (e.g,, energy materials in BTU's), are amenable to mathematical formulation as a linear programming model.

The treatment of the demand structure of the economy in BESOM, FREPAS, and QMC-WEM is limited to an exogenous specification of demand requirements for the various materials, PIES offers more macroeconomic content. It has been developed to provide a comprehensive framework within which to evaluate specific energy policy issues and changing world and domestic conditions and to assess the impacts of alternative policy options. Specifically, it is designed to generate projections and impact assessments required for Project Independence, including planning estimates depicting possible states of the U.S. energy system, recognizing the effect of relative prices, the potential for fuel substitution, and the technological constraints on energy supplies. PIES is composed of an econometric demand model and a linear programming supply model coupled together, and it forecasts both quantities and prices of fuels on the basis of a market-clearing mechanism which iteratively yields a balance between supply and demand. More specifically, the demand model is embedded in the supply model. In searching for the equilibrium point between supply and demand, the model iterates in a recursive fashion until the market-clearing prices and quantities of energy products for a given year are found. The demand model used by PIES does not offer as much detail on the demand structure of the economy as the previously discussed input/output models, but it does provide the means for examining policy questions that can be stated in terms of changes in supply and demand curves, modification of energy production distribution technologies, or operational constraints on the energy supply system. However, an unlimited physical availability of fuels is still implicitly assumed, and there is no provision for consideration of second-order effects.

d. Break-Integration Method of Combining Models. The process of using models to produce materials in format ion for policy makers involves both human judgment and data processing. Although in theory much of the judgment might be programmed into the models, in fact, a break-integration concept—whereby human judgment interacts with the various models for any given analysis—presently offers the most effective way to utilize available models. Thus, in forecasting the demand for a given material, the analyst will break in between the analysis of the time series and the computation of the forecast to select the appropriate forecasting model. Similarly, in assessing the economic ramifications of demand or supply adjustment options to solve an anticipated shortage, the analyst will break in after exercising the respective materials consumption and production models in order to analyze intermediate results.

Figure IV–4 depicts a concept for a break-integrated policy analysis facility, The system is composed of a data base, a number (n) of forecasting and impact assessment models, a master model, and a man/machine interface, For a materials policy support facility, the *n* models could be, for example, the nine models outlined in figures IV-1 through IV–3, Each model includes its own individual data base in addition to the generic data base. Furthermore, each model can be used either individually or in conjunction with other models via the master model, The master model would provide the interface between the analyst and each model, and between each pair of models. To interface between the analyst and the data base, the master model would include data analysis programs and model-building techniques in addition to tabular and graphic display capabilities. To interface between the analyst and the models, the master model would include programs to access and exercise each one of the models. Furthermore, for one or more pairs of mutually complementary models, it would include programs to transform the output of one model into input for the other model. In order to validate the decisions of the analyst at the break, his actions should be recorded along with the reasons for his selection,

Figure IV-4. Concept of a Break-Integrated Policy Analysis System



Active involvement at the break by policy makers would be another way of ensuring valid decisions. In any case, policy makers should understand the assumptions that were made in running and/or integrating the various models. As an example, the break-integration method could be used in an analysis of the use of energy materials in the United States, This involves consideration of energy requirements and the energy production and distribution system. These systems interact; moreover, they are affected by foreign considerations. Thus, a domestic economic energy system model, such as INFORUM, should be complemented with an international model, such as QMCWEM, Because of the difficulties associated with operating large-scale models, it may not be possible to accomplish their full integration. However, it may be possible to develop the capability to exercise both models by using the break-integration technique. The structure and information content of INFORUM and QMCWEM, presented in figures IV-2 and IV–3, are indicative of some of the interfaces that would have to be worked out to use them in a break-integrated fashion.

D. REQUIRED IMPROVEMENTS IN MATERIALS INFORMATION SYSTEMS

Although the review was necessarily limited, and the results should be interpreted with care, several areas of deficiency, vis-a-vis the integrated capabilities were noted. With respect to the ways agencies (a) collect, handle, and analyze data and (b) present resulting information, there appear to be six key areas in which significant improvements would have to be made to achieve the kind of performance envisioned in the integrated capabilities. These are summarized in table IV–8 along with an assessment of their criticality.

1. Completeness of Data Bases

Among the most serious deficiencies are insufficient data on private domestic reserves and inadequate data on foreign holdings, resources, reserves, productive capacity, consumption, etc. The number of materials now covered by existing systems may also be inadequate for the integrated capabilities. For example, the Bureau of Mines' MAS currently has reasonably complete coverage on only four minerals; plans are in place to increase that coverage to 36 minerals over the next 5 years. In addition, current systems do not cover all the different kinds of data the improved system would require. Thus, for example, more complete information on recycling would need to be acquired.

2. Accessibility

This problem area refers both to problems in obtaining needed data, primarily from private industry, and in transferring data and information among agencies. Experience of existing materials information systems in acquiring data from industry show these issues to be particularly sensitive. Controversy abounds on the merits of setting voluntary versus compulsory submission requirements. Many of the agencies, often those that have established close working relationships with industry, believe that voluntary methods yield higher quality data than do mandatory regulations. Other agencies feel that only mandatory methods can ensure necessary completeness and reliability. There appears to be little objective experience available to weigh the claims, Experiments to perfect techniques for collecting geological and other kinds of data via remote sensing from satellites are underway. Such a capability could make it easier to obtain needed information, especially in undeveloped areas where data on resources and

Table IV-8.-Criticality of Problem Areas in Selected Systems

Information System Elements	Problem Areas					
	Completeness	Accessibility	Standardization	Reliability/ Accuracy	Resoponsiveness/ Timeliness	Statistical/ Analytical Capability
Data Collection	Serious	Critical	Critical	Serious	Moderate	Serious
Data Handling	Moderate	Serious	Serious	Moderate	Serious	Not Applicable
Analysis	Moderate	Moderate	Moderate	Serious	Moderate	Critical
Reporting	Serious	Serious	Moderate	Moderate	Serious	Not Applicable

Critical-Critical level of concern; critical need for improvement inferred.
Serious—Serious level of concern; serious need for improvement inferred.
Moderate-Moderate level of concern; occasionally cited as area in need of improvement.

reserves are sparse. Early results are promising. However, much refinement is apparently needed before fully practical satellite systems can be applied. [2]

With regard to data/in formation transferability, the review indicated that only a limited interchange was being made among agencies at the unprocessed data level. Most information transfer occurs via formal, serial reports published by the various agencies. Sharing of information at the raw data level and use of processed results before formal publication (conditions inherent in the conceptual system) have been inhibited by several factors, Because of agreements made with firms supplying needed information, some data is not available to all interested parties; for example, data collected by ERDA was not made fully available to the Bureau of Mines, Often, an interested party does not know that the desired information exists, or the data is not available in a suitable form to enable transfer from one agency to another, Even when the information exists in a computerized format, differences in format and definition often make it difficult for a second party to understand it,

3. Standardization

This problem area refers both to common standards and data formats (technical details) and to the more difficult issue of establishing common definitions of terms. Shared use of current systems is impeded by inconsistent use of units of measure (long versus short ton); confusion over meanings of terms (bauxite and aluminum are used interchangeably); and incompatible time-tagging of data (some data corresponds to shipping date, other data to contract date), These conditions introduce double counting and gaps and limit the ability to compare and aggregate data from different sources. It is particularly troublesome to the industrial user of the information, who normally has no means to reconcile inconsistencies.

4. Reliability/Accuracy

While each agency applies judgment in accepting data submitted to it, there appears to be limited formal opportunity or technique to validate input. This applies particularly to data submitted voluntarily, but it also applies to data which must be provided by law.

5. Timeliness

This problem area refers to the turnaround time in responding to requests. Timeliness does not appear to be a critical constraint. However, it would be an important consideration in responding to unanticipated shortage situations. For many planning studies, the acceptable turnaround time may be measured in weeks, but for crisis situations, it may be days or even hours. Assuming other system deficiencies (completeness of data bases, standardized formats, etc.) have been reconciled, improved timeliness, if needed, could be achieved (but at higher cost) through use of more powerful data processing hardware.

6. Statistical/Analytical Capability

This problem area refers to the use of forecasting models. The review disclosed that while no agency was using models covering all the functions included in the integrated capabilities, many agencies were experimenting with using several models akin to those discussed here.

[2] Experiments to perfect these methods are underway. A new satellite, LANDSAT D. with approximately three times the resolution of current satellites. LANDSATS A and B, is planned to be launched, but not before 1981.

E. SUMMARY

The large number of agencies operating materials information systems, each focusing on particular aspects but dependent on many agencies' systems for input data, confirms the need for more integration. The existing array of Government systems provides a strong starting point for that development. Many of the deficiencies noted in the systems examined here have been recognized by their developers. In many cases, programs are underway to correct them. particularly in upgrading the data bases.

It should be recognized that some of the existing systems have been in the developmental phase for decades; most of the more automated systems are relatively new. Almost all were designed to address specific, pressing single-agency problems. Coordinating and integrating them, particularly as they expand, to achieve the kind of functions envisioned in the integrated capabilities will present a significant challenge, The options for effecting this upgrading are discussed in the next two chapters.

Chapter V

OPTIONS FOR ACHIEVING THE INTEGRATED CAPABILITIES

Chapter V

OPTIONS FOR ACHIEVING THE INTEGRATED CAPABILITIES

There are a number of options available to Congress and the President for improving materials information and analysis in accordance with the needs previously identified in Chapters I-IV. These options range from no direct action, to hearings, executive orders, and finally to legislation.

In illustrating the implementation possibilities of the last option, three alternative systems approaches for achieving the integrated capabilities were examined.

- **Approach A would employ an interagency committee or congressionally authorized group to coordinate the existing materials information systems;**
- **Approach B would create a full-time organization which would make step-by-step improvements in the existing information systems and add new supplementary capabilities as required;**
- **Approach C would create a central program management office which would first design the improved capabilities from the "top-down," then would decide what, if any, portions of the existing information systems could be utilized in the new design.**

The relative merits of the three approaches are compared and their order-of-magnitude costs are developed.

A. INTRODUCTION

A number of options are available to Congress and the President as a means of improving current Government materials information systems in accordance with the needs previously described in chapters I-IV. These options range from no direct action, to hearings, oversight, executive order, and finally to legislation. The options focus particularly on executive and/or legislative actions to provide integrated materials information capabilities in support of policy-level decision making.

The analysis in earlier chapters strongly suggests that, without direct and concerted action, the legislative/executive branch needs for improved materials information in support of public policymaking are unlikely to be met through the natural evolution of existing materials information systems. However, the analysis also indicates that increased Federal commitment to such improvement through one or more of the possible legislative/executive options will not by itself insure that existing systems evolve to meet priority needs. Regardless of the level of commitment, additional organization and integration seems essential.

B. LEGISLATIVE AND EXECUTIVE IMPLEMENTING OPTIONS

A **number** of options are available to Congress and the President for the provision of improved materials information and analysis in accordance with the needs previously identified. This section describes the range of legislative/executive options and discusses the major advantages and disadvantages of each. The focus is on executive and/or legislative action to provide improved materials information and analysis in supporting policy-level decisionmaking. However, some actions include an important role for the private sector, and some if not most of the improved information and analysis could be useful to the private sector.

1. Evolution of Current Systems Without Direct Action

A materials information "system" does currently exist, at least in a loose sense, as indicated by the survey and interviews. Many kinds of materials data are collected by numerous public and private sector entities with varying reliability and completeness. Based on these data, certain kinds of materials information (summaries, analyses, and forecasts) are available, although not always readily accessible and frequently in noncompatible formats. Nonetheless, a system of sorts does exist, especially for the handful of experts and specialists who know the parts of the system well and can pull things together, at least in their own minds.

The first option available to Congress and the President is to do nothing, that is, to let the current systems continue to evolve without direct intervention. The essential question, of course, is whether the current systems will improve quickly enough to achieve the capabilities.

a. Evolving Systems in the Federal Government. The survey of Federal Government systems reveals that efforts are underway in several agencies to improve or upgrade existing systems. However, the rate of progress appears to be quite slow. For example, the Department of the Interior's Bureau of Mines has a Minerals Availability System (MAS) in early stages of development. The system now includes data on only a few commodities and is therefore not extensively used, although the 5-year plan for MAS includes 32 minerals, In the Forest Service, Department of Agriculture, existing data bases and analysis techniques are being integrated into a forestry information system, which is expected to provide more effective support for the Forest and Rangeland Renewable Resources Act of 1974, Likewise, in the Department of the Interior, a Mineral Analysis and Policy System (MAPS) is under development to expand data collection, analysis, and forecasting activities in minerals-related areas, The Department of Commerce, Bureau of Domestic Commerce, is in the process of developing and implementing an Early Warning System designed to (1) forecast possible supply dislocations, (2) analyze the impacts of such dislocations, and (3) recommend policy options to avert or mitigate such dislocations.

But despite these signs of progress, major problems are identified in the survey of existing systems presented earlier. Overall, the natural evolution of Federal Government systems can be expected to lead to gradual improvement within agencies. However, little improvement can be expected with regard to the lack of effective integration of materials supply and utilization information which must cross agency lines.

b. Evolving Systems in State Government and the 'Private Sector. A few States (including Alaska, California, Illinois, and Oregon) are developing fairly comprehensive information systems on some materials for parts of the materials cycle, Yet in general, materials information systems at the State level are currently not as well developed as at the Federal level and by comparison are evolving slowly.

Survey results indicate that in the private sector many of the larger firms in materials-related industries have developed their own information system on some parts of the materials cycle. Many also have statistical and analytical capabilities with regard to basic materials trends affecting their own activities. By comparison, smaller firms generally cannot afford a substantial in-house effort. Some of the larger firms are making efforts toward upgrading their systems and introducing additional capabilities. But progress appears to be slow, in part due to lack of confidence in forecasting. inadequate conceptual frameworks for handling exogenous variables, incomplete data, and legal and competitive barriers to cooperation.

A few small private sector information service firms (e. g.. Battelle Memorial Institute, Data Resources, Inc., and Chase Econometrics. Inc.) provide technical data, as well as referral modelling and forecasting services. These firms thus fill some of the gaps in the information systems of materials-related companies. However, the natural evolution suggests a centinuing mismatch between the information needs of the private firms (and Government agencies) and the data collection and analysis techniques developed by the information service firms, universities, and "think tanks. "

The evolution of current systems is unlikely to 1) promote the most efficient and effective governmental and private sector responses to materials problems; 2) provide adequate data and analysis for public and private sector materials policy makers; and 3) solve the problems of interagency information transfer within the Federal Government and integration of materials supply and utilization information. Coordination and planning of materials information activities between the Federal and State governments and the private sector are unlikely to improve substantially.

2. Legislative Branch Options Short of New Authorizing Legislation

Congress has available a number of possible options short of legislation to provide various kinds of improved materials information.

a. Congressional Options To Provide Improved Materials Information Within the Legislative Branch. Congress can act through existing congressional offices and agencies which already have a general mandate compatible, at least in part, with the needs for improved materials information. The major possibilities here lie with the Congressional Budget Office, the General Accounting Office. the Congressional Research Service, and the Office of Technology Assessment, all supported by the evolving congressional information system. These offices, along with the congressional committees, serve an important function in filtering and translating data and information into a policy analytical format consistent with the needs of members of Congress.

The first possibility is action through the Congressional Budget Office (CBO). The CBO was established by the Congressional Budget and Impoundment Act of 1974 to provide Congress with high-level analytical capability in reference to the Federal budget and the relationships between allocations of resources (through the budget) on the one hand, and national priorities and quality of life on the other, The Act requires CBO to develop "a detailed structure of national needs which shall be used to reference all agency missions and programs, " and to study proposals for " improving analytical and systematic evaluation of the effectiveness of existing programs, and developing techniques of noneconomic as well as economic evaluation measures. "

The second possibility is action by the General Accounting Office. While CBO has continuous responsibility for analysis of matters involving the budget, the GAO generally becomes involved only at the specific request of Congress, However, because of the high priority of the energy -environment-resources area, and the large number of related requests from Congress, the GAO could assume an expanded role—particularly with regard to the monitoring and validation of materials data. Under the Legislative Reorganization Act of 1970, GAO is given the general responsibility to review and analyze Government programs, "including the making of cost-benefit studies, " which can be a useful technique in the materials area.

Two other congressional agencies, the Congressional Research Service (CRS) and the Office of Technology Assessment (OTA), may also carry out activities related to new or improved materials information. The CRS maintains a group of materials specialists for briefing Congress on materials issues, keeping track of materials-related legislation and reports, and performing research in selected materials area. Consistent with the Legislative Reorganization Act of 1970, CRS is empowered to provide improved information support to Congress, and could serve as a location for an expanded materials analytical capability and/or a materials referral service,

The Office of Technology Assessment could itself maintain a continuing role in the materials information area, building on the expertise developed through this and other materials assessments. In establishing OTA, Congress recognized that "the present mechanisms of the Congress do not and are not designed to provide the legislative branch with (adequate) information" on the "consequences of technological applications and emerging national problems. " Materials appears to be a national problem area to which OTA can justifiably give a degree of continuing attention for some time to come.

Support of materials-related activities of the offices described above can be provided by the evolving congressional information systems. Provision of computerized information support to Congress is shared primarily between the House Administration Committee, the Senate Rules and Administration Committee, and the Library of Congress. As yet there is no single unified system, but development has progressed to the point that improvements in CBO, GAO, CRS, and/or OTA materials-related analytical capabilities can likely be supported via the evolving congressional information systems. Computer terminals are already available in a number of committee and member offices, with further expansion expected. Efforts are underway to gradually enlarge the range of computer-based support services available to Congress for the provision of information in a wide range of areas, including materials.

Possible advantages and disadvantages of congressional actions to provide improved materials information with in the legislative branch are summarized in table V-1. While all materials in format ion needs cannot realistically be met within Congress, improvements within the legislative branch will strengthen congressional capabilities and independence in materials policymaking, regardless of actions taken by the executive branch,

b. Congressional Options To Provide Improved Materials Information Via the Executive Branch. Congress has several options, short of new authorizing legislation, in seeking to provide improved materials information via the executive branch. The most important of these options includes the use of congressional hearings, the exercise of oversight and investigative powers, and the possibility of congressional resolutions.

Through the hearing process—both substantive and appropriations—congressional committees with relevant jurisdiction can encourage Federal executive agencies to take actions to provide improved materials information, e.g., with respect to data base discipline and compatibility, improved forecasting capability, and better coordination and integration.

Problem areas, such as materials information transfer within a particular agency or between two agencies, can become a focus for special attention through oversight by congressional committees with relevant jurisdiction. An even stronger measure might involve the use of the congressional investigative power to obtain executive information as to the inadequacies of the present materials data and analysis, or (in an extreme case) to compel

Table V-1.—Possible Advantages and Disadvantages of Legislative Branch Options Short of New Authorizing Legislation

Advantages	Disadvantages
Congressional Options to Provide Improved Materials information Within the Legislative Branch	
Will strengthen congressional capabilities in the materials area, regardless of actions taken by the executive branch.	May spread thin the resources of congressional offices.
Will afford Congress a somewhat higher degree of independence in materials policymaking.	Will not be sufficient for meeting all materials information needs, some of which require ongoing administrative functions which are outside the capabilities and role of Congress.
May generate greater congressional confidence in materials data and analysis since information will be screened and interpreted by congressional offices instead of or in addition to the executive agencies.	
Congressional Options To Provide Improved Materials Information Via the Executive Branch	
Will encourage or place pressure upon the executive branch to improve materials data and analysis.	Will not normally be legally binding on the executive branch.
Will bypass the difficult process of enacting new authorizing legislation.	May not ensure an effective executive response,
May at least to some extent increase the responsiveness of established materials agencies.	
Congressional Options To Provide Improved Materials Information Via the Private Sector	
May encourage the private sector to improve materials information.	May not be taken seriously by the private sector.
May help give greater priority to materials information activities in the private sector.	May not ensure a private sector response sufficlent to meet priority information needs.
May help increase private sector involvement in and support for improving materials information.	

attendance of witnesses or submission of documents deemed pertinent to these inadequacies. Such investigations may be justified under congressional rules for holding administrative agencies accountable for their activities or to lay the informational basis for legislation.

Finally, short of legislation, Congress can also express its strong concerns about having better materials information and analysis through a resolution, directed toward the executive branch. However, since bills are preferred over resolutions in important matters, new authorizing legislation seems more appropriate here. House, Senate, and joint resolutions can additionally be used to implement improvements in legislative branch materials information, that is, to state what the internal policy of Congress shall be with regard to the materials information area.

Possible advantages and disadvantages of congressional options, short of new authorizing legislation, to provide improved materials information via the executive branch are summarized in table V-1. While such options will encourage the executive to improve materials information and bypass the difficult legislative process, they will not normally be legally binding and may not ensure an effective executive response.

c. **Congressional Options To Provide Improved Materials Information Via the Private Sector.** Policy statements by individual members of Congress and groups of Members can help stimulate private sector efforts toward provision of improved materials information, without enacting new authorizing legislation, Beyond that, through hearings and oversight in materials-related areas, Congress can encourage Federal agencies to allocate their resources flowing to the private sector in accordance with the need for improved materials information, under existing legislation in a wide range of materials-related areas, Greater priority can be given to improving materials information activities in the private sector, including the establishment of centers and institutes for materials information research, development, and demonstration,

Possible advantages and disadvantages are summarized in table V-1. While these options may to some extent encourage the private sector to improve materials information and increase private sector involvement, they may not insure a private sector response sufficient to meet priority information needs.

3. Executive Branch Options Short of New Authorizing Legislation

Another option is executive action, short of new authorizing legislation but more than the evolution of current systems, to provide improved materials information.

First, a Presidential proclamation or policy statement—while not having the force of law-can set an overall direction or thrust to improving materials in formation. Next, although the President's power to issue executive orders has been restricted by Congress, especially in regard to reorganization plans, some materials information needs can be met through executive and/or agency order. Examples include a materials referral service and perhaps data base standardization. Third, various specific improvements in current materials information systems could be implemented via an OMB directive or bulletin.

Table V-2.—Possible Advantages and Disadvantages of Executive Branch Options Short of New Authorizing Legislation

Executive Options to Provide Improved Materials Information	
Advantages	Disadvantages
May promote the greatest cooperation of executive agencies while minimizing organizational disruptions.	May not stimulate the public debate necessary to focus attention on materials information.
May promote the involvement of business and Industry.	May not provide an effective solution to materials information problems due to limitations on executive actions.
May draw upon the expertise of the private sector in materials data collection and analysis.	May not generate sufficient congressional support.

Finally, a somewhat different approach would involve grants and contracts to the private sector without further legislation. Federally supported materials research, development, and demonstration support programs, including energy conservation, environmental, and land use planning activities, in the private sector could be adjusted through executive action to aid in improving materials information. Such adjustments could relate to: (a) materials forecasting/modelling capabilities. (b) clearinghouse/referral capabilities in specialized areas of materials i n formation, and (c) statistical/analytical capabilities with respect to the cycle of materials supply and utilization.

Possible advantages and disadvantages are summarized in table V-2. Executive branch actions taken alone may promote cooperation among executive agencies and the involvement of the private sector, but may not stimulate the public debate and generate the congressional support needed to focus sufficient attention and resources on materials information problems.

4. Options Through Legislation

Up to this point, the legislative/executive options discussed would be accomplished within the existing systems and institutions, However, any actions to implement a major program from the standpoint of institutional changes and/or substantial expenditure of funds over an extended period of time will generally require legislation in view of the legal requirements, the level of resources involved, and political considerations, among other factors. Legislation could be designed to make current information systems more effective and efficient, and to implement the integrated capabilities by building on some or all of the systems now scattered throughout the Federal Government,

Possible advantages and disadvantages of implementing the integrated capabi1ities through Legislation are summarized in table V-3. Legislation will permit a more comprehensive approach, will allow interested parties to develop alternatives, and will help assure wider participation in decision process.

Table V-3. Possible Advantages and Disadvantages of Options Through Legislation

Advantages	Disadvantages
Will permit a more comprehensive appreach than executive or congressional action short of legislation.	May take longer than executive action due to delays in the legislative process.
Will allow many interested groups and organizations to develop alternative plans for consideration by Congress.	May stimulate a divisive political debate.
Will help assure wider participation in the decision whether or not to create a new or improved system.	May cause greater disruption in the Federal bureaucracy and potential resistance to change.
Will generate wider public awareness and interest in materials information and related areas.	May raise expectations to unrealistic levels.
Will permit a more focused congressional statement of purpose.	
May actually speed up action if a sense of urgency and widespread consensus is established on the need and priority for a new or improved system.	

If a sense of urgency and widespread consensus is established, legislation may speed up action, However, legislation could take longer, since one function of political debate is to bring out a wide range of views and opinions.

C. ALTERNATIVE INFORMATION SYSTEMS APPROACHES

In order to illustrate how the last option, actions requiring new authorizing legislation, might be implemented to improve the current Federal materials information systems, three alternative information systems approaches were identified, The social, political, and other impacts of the approaches are discussed in chapter VII. All three approaches can achieve the integrated capabilities, but with differing degrees of effectiveness and at differing costs,

Consideration of the range of options for improving current Federal materials information systems led to the identification of three basic approaches for meeting the needs discussed in chapter III.

- Approach A—Coordinated Systems Evolution. This approach centers on the use of a coordinating group to organize activities of the current Federal systems as they exist and are expected to develop within the context of current 5 year plans, Solely through coordination, an attempt would be made to achieve the desired integrated capabilities. The various agencies would continue in their present directions, but the coordinating function would encourage increased communication and cooperation among them to promote greater effectiveness, This approach involves only minimum, if any, organizational change. Existing agencies would be assigned responsibility for functional requirements not now being performed, including the collection of data required for the improvements, These activities are also essential requirements for approaches B and C.
- Approach B—Directed, Step-By-Step Upgrading of Existing Information Systems. This approach is also based on the use of Federal systems as they exist and are expected to develop, but it would have an oversight function assigned to a directing office, which may be an existing or new agency. This office would closely follow the development of all Federal materials information systems and direct and focus activity toward achieving the desired integrated capabilities. The oversight office would determine the resources needed, compare them with existing capabilities, and fill the gaps by assuming responsibility itself or by assigning it to other agencies, This approach could be implemented in numerous ways. To illustrate its flexibility, a development encompassing three sequential steps is discussed.
- Approach C—New Information System. In contrast to the other approaches, this approach envisions developing the integrated capabilities from the top down. A strong centralized management group would be established to direct the program, It would determine what facilities and services were needed and how they should be implemented, making use of existing systems only where they clearly met ultimate requirements.

  To the extent that existing facilities met requirements of the top-down plan, they would be used. But, as compared with approaches A and B, there would be greater prerogative to acquire new facilities and less mandate to stay with existing systems of marginal use.

Table V-4 lists the major characteristics of each approach.

In examining alternative approaches, there are few basic options from which to choose:

Table V-4.—Summary of Alternative Systems Approaches

Approach Characteristics	Approach 1	Approach 2 Step 1	Approach 2 Step 2	Approach 2 Step 3	Approach 3
Supports improved capabilities	Yes	Yes	Yes	Yes	Yes
Meets materials information policy needs	Partially	Partially	Partially	Yes	Yes
Design philosophy	Coordinated evolvement of existing systems	Directed improvements to upgrade existing systems			Top-down, requirements design-driven to establish needed system
Uses existing* Federal materials information systems	Yes	Yes	Yes	Yes	Partially
Creates organization to oversee operation of existing systems	(Coordination group only)	Yes	Yes	Yes	No
Creates organization to establish new* information systems	No	No	No	No	Yes
Provides the following new* services:					
Referral	Maybe	Yes	Yes	Yes	Yes
Clearinghouse	Maybe	No	Yes	Yes	Yes
Query management	Maybe	No	No	Yes	Yes
Information exchange (including standards)	Maybe	Yes	Yes	Yes	Yes
Summary data base	No	No	No	Yes†	Yes‡
Statistical services	No	No	No	Yes†	Yes‡
Modeling services	No	No	No	Yes†	Yes‡

Notes:

● "Existing" includes planned growth or normal evolution; "new" involves improvements beyond that.

† New summary data base and analytical services to supplement detailed data bases, statistical analyses, and forecasts of existing system for critical materials and to-aid in the exchange of information among components of the existing system.

‡ All needed data collected, validated, and stored as part of new information system; necessary analytical services for system concept provided.

(a) one can improve cirtical parts of the present systems; (b) one can improve major parts and add new parts to achieve the desired level of performance; (c) or one can design a totally new system to replace the existing systems.

Analysis of the existing information systems shows that doing nothing is unlikely to achieve the desired capabilities, Some of the needed functional requirements are not met at all and need to be added. Others need to be improved because materials information is not managed so that it is sufficiently complete, accurate, current, standardized, and accessible. Moreover, even if these individual deficiencies were corrected, overall performance would still be inadequate without substantial improvement. As noted in chapter III, the functional requirements are highly interrelated, and there is a clear need to integrate these functions so that data on supply and utilization could be more readily exchanged and analyzed.

In implementing the integrated capabilities described in chapter 111, actions must be taken to provide a range of necessary services. Prospective users must have an awareness of what data exists and how it can be accessed; and they must have assurance that data obtained from different sources are consistently standardized. They need to know what standards apply. They also need to know what models are being used and what constraints exist in using them. In short, they need to know how to specify and obtain the "outputs" they require. In theory, the components that perform these services—locating data, establishing standards, handling queries, etc--coould all be implemented at the same time; moreover, they could be completely integrated and highly automated. In practice, however, it is more likely that the integrated capabilities will be added over time, and the desired level of services will be attained in steps. Initially, many steps will be accomplished manually, e.g., assisting users in locating information. Later, these services might be accomplished using more sophisticated, automated techniques.

Considering the broad range of uses to which the integrated capabilities could be applied, the following set of basic information services have been identified. All three systems approaches provide the services; however, they achieve them in different ways, on different time schedules. and to different levels of performance:

- Materials Referral Service.—This service would provide visibility and accessibility to needed information for policy makers.
- Materials Information Exchange Service.—This service would apply standards within the entire Federal information system, ranging from the development of a common vocabulary to be used in the select ion, analysis, and reporting of materials information to the development of common data formats and data handling procedures to be incorporated within each existing Federal information system. Such materials information exchange service, interfacing with all components of the existing Federal information system, would facilitate data exchange and would accomplish the meaningful interchange of data inherent to the integrated capabilities envisioned.
- Clearinghouse Service,—This service would be utilized to help users obtain answers to clear-cut, factual questions. The Clearinghouse would not provide analytical support. It would only obtain necessary serial publications and reports from the existing Federal materials information systems and forward them to the user.
- Summary Data Base Service.—This service would collect required information on supply and utilization at the appropriate level of aggregation from the existing Federal information systems. It would also handle any format conversions and data translations that were required to include the information in the summary data base.
- Query Management Service.—This service would help users obtain answers to more complex questions. It would access the summary data base for data, prepare statistical summaries showing historical trends, and possibly even run models on selected data. It would be staffed with materials specialists and economists who would work with users to help interpret their questions and obtain answers.
- Routine Statistical Services, -These services would be responsive to both periodic and one-time user requests, possibly issuing a semiannual or annual publication of summary statistics for all critical materials. They might also include the capability for analyzing summary historical data to answer specific questions, such as "What trends are developing in the domestic use of copper?" These kinds of services are needed to interpret and

display trends in critical materials to alert policy makers to potential scarcity situations.

- •Modeling Services.-These services would address "what if" type questions in response to user requests. They might include issuing a semiannual or annual forecast of potential shortages using the index of scarcity concept discussed in chapter 111. They might also provide answers to special requests for running appropriate models on materials situations. These analytical services would be particularly needed by users who do not have their own facilities, for example, Congress. The interpretation of the data, the setting of assumptions, the selection of parameters. etc. would be performed by the user's own staff.

These services are not independent but are supportive of each other, For example. establishment of the materials information exchange service would facilitate the establishment of materials referral service; establishment of the summary data base service would facilitate statistical services,

The following sections further detail each approach, not as a recommended evolution, but as illustrative of the ways they might reasonably be implemented.

1. Approach A: Coordinated Systems Evolution

This approach permits the current materials information systems to continue to evolve without a central group having direct authority over them, However. a coordinating group, probably comprised of representatives of the institutions now operating the systems, would guide the evolution. The coordinating group would establish common objectives and clearly delineate gaps and overlaps in institutional responsibilities, which could be corrected through executive directives (perhaps also with new legislation), Clear and separate responsibilities for information management of a particular class of materials to achieve specific functional requirements could thus be sought. However. without a central group with a measure of direct authority overseeing the improvements (as included in approaches B and C), this evolution could vary in degree by functional requirements or by class of materials, since the evolution would likely be driven by the latest perceived problems (for example, new fuel shortages) or other external influences,

This approach is most susceptible to redirection of institutional resources to address the short-range problems pertaining to a particular agency's mission. This could adversely impact the ability of existing systems to achieve the basic and supplemental functional requirements within reasonable time. It is important to note that current institutions have recognized the information management problems within the purview of their own institutional missions and have initiated plans to improve their information systems. Both short and long-range improvement plans are in place to upgrade information systems. Thus, there is a substantial base from which development evolution could start. Some of the plans upon which this approach could be based are described as follows.

a. Department of Interior. The Department of the Interior's Minerals Analysis and Policy System (MAPS), announced in September 1974, has two projects related directly to the management of materials information:

- Expanded data collection and analysis of domestic and international sources of critical minerals and materials, including appraisal of existing and potential ore deposits, processing facilities, transportation systems, labor supplies, and a variety of geologic, economic, and institutional data on operating mines which produce key mineral commodities. Paramarginal mineral deposits will be included to assess supplies at various price levels. Hypothetical resources will be considered to ensure identification of materials presently convertible to reserves.

- Expansion of the Department of the Interior's forecasting capabilities, as an improved guide to informed U.S. Government decisionmaking on both domestic and world mineral markets. Several different forecasting methods will be used in order that one will serve as an accuracy check on others in making appropriate long- and short-term forecasts which can assist in the orderly functioning of the market system.

The Office of Minerals Policy Development (OMPD). the U.S. Geological Survey (USGS), and the Bureau of Mines (BOM) were assigned major roles in this effort. The OMPD Report, Critical Materials: Commodity Action Analyses (March 1975), is an analysis of four supply/demand problems in critical imported materials. This study did not use data directly from an automated data base of supply/demand; however, as mineral reserves data are added to the Minerals Availability System (M AS). this capability is planned.

b. Department of Agriculture. The Forest Service is developing a long-term plan under the Forest and Rangeland Renewable Resources Planning Act of **1974** (P.L. **93-378)** that will consolidate and develop its use of data bases both to manage the national forests and provide supply and demand information on timber on public and private lands. including:

- Resource estimates of timber;
- Trends in consumption and prices;
- Prospective demand. supply, and price outlook to 2020; and
- International trade and resources.

Further development of the already advanced Forest Service Information System will consolidate and standardize the timber data banks and provide more extensive statistics, referrals, and reports.

c. Federal Energy Administration. The Integrated Petroleum Reporting System Task Force, with representation from the major FEA offices currently operating or using petroleum reporting systems, was formed to improve petroleum reporting systems in order to meet requirements imposed as a result of new legislation, Specifically, its goals were to minimize the gaps and remove redundancies and inconsistencies in data and to establish a cost-effective way to alleviate the reporting burden on the industry. As a result, the implementation of the Petroleum Reporting System Phase I (PRS) has recently been initiated within the constraint of using existing data elements. Further upgrading of this system is planned.

FEA has also established the National Energy Information Center (NEIC) in response to a requirement for a national clearinghouse for energy information, The Center serves all sectors of the materials community by:

- Responding to inquiries;
- Referring to data sources;
- Providing information analysis and research;
- Maintaining an energy library; and
- Producing indexes, bibliographies, periodic and special technical reports.

FEA is developing a computerized Federal Energy Information Locator System (FEILS) to provide information on the existence, location, and characteristics of energy or energy-related data to a detailed element level. At the present time the system contains entries of the **260** energy programs identified by an interagency task force. Summaries of data programs have been validated by source agencies for completeness and accuracy.

Once the user finds the location of the information that he desires, he can then request the assistance of the National Energy Information Center to obtain that information.

These activities are illustrative of those taking place which will significantly improve materia1s inform at i on m a n age m en t capabilities to address the basic functions and, ultimately. the supplemental functions.

There are two types of deficiencies that need to be corrected if the existing materials information systems are to accomplish the basic functions. First, some functions being addressed by some institutions are not being performed adequately; they could be corrected by directing each responsible agency to perform the needed function (such as improving resources and reserves estimation) in the manner required. The second deficiency involves developing a capability for basic functions which are not currently being performed, such as monitoring recoverable materials and assessing price impacts.

In approach A a coordinating group would evaluate which basic functions are already being performed by each institution and would assess the capability to perform the functions in the manner required, Institutional agreements would result in new directives within each agency to remove its own inadequacies, without disrupting other missions being performed. Also to be considered by the coordinating group would be the question of what agencies were best equipped to carry out or develop the missing functions. For example, the Bureau of Mines already monitors information on the materials cycle for the nonfuel minerals class. While an agency could be established or missioned in the Department of Commerce to collect missing elements, responsibility for monitoring of all these pieces might also be considered a BOM mission. Because of the economic considerations involved in the basic functions, particularly the supply/demand analysis leading to a calculation of an index of scarcity and its subsequent price impacts, the Office of Minerals Policy Development might also be involved in BOM in integrating these functions for that class of nonfuel minerals.

This logic could also be applied to other classes of critical materials, and a single existing institution could be given the integration responsibility for that material or class of materials. In this manner, a coordinator might be established for each critical material or class of materials to ensure that the required system interconnections between functions were achieved. For example, the Department of Agriculture might continue to be responsible for both the forest products/paper materials class and the nonfood agricultural materials class. In order to do so, it might obtain some needed data from the Department of Commerce. The Federal Energy Administration might be responsible for integrating the mineral fuel class of materials, obtaining needed data from both the Bureau of Mines and the Department of Commerce. In fact. its relationship with BOM for mineral fuels might be similar in some respects to its relationship with OMPD for nonfuel minerals. Other classes representative of processed materials might be handled by the Department of Commerce. These assignments would be very similar to current institutional responsibilities for these materials,

Basic information services such as the materials referral service and clearinghouse service could also be implemented within this approach. By mutual agreement. an existing office or agency would take on the responsibility. Once again, these services could be subdivided by class of material so that possibly five or more such services would be provided. (FE A already runs a referra1 a n d clearinghouse service for energy.) However. it might be more difficult to fully accomplish the services (particularly the clearinghouse service) in this approach because access to data would cross institutional boundaries and would require close cooperation among the existing institutions and users, Approach A could, in time, achieve the improved capabilities that might meet several of the needs identified in chapter III and might well improve the data available in regular publications. However, it probably would not meet all the needs of decisionmakers who want timely access to comprehensive, aggregated materials information presented in convenient, easy-to-understand formats.

2. Approach B: Directed, Step-by-Step Upgrading of Existing Information Systems

Approach B, which also makes extensive use of the existing materials information systems, has two characteristics which distinguish it from approach A: (1) oversight authority by a single agency, and (2) a step-by-step development philosophy involving a continuous evolution and reevaluation of ultimate objectives.

In approach B. a specific agency would be given oversight authority for all existing Federal materials information systems. This agency would be charged to understand the operations of all information systems and would be given authority to ensure that the systems supported established government-wide objectives, improving them as required. Various, alternatives for the location of this agency and its authority are discussed in chapter VI. At a minimum, it would have permanent staff, budgets, and authority to access the existing systems, understand their operations, establish plans and budgets for needed improvements, and ensure their implementation. The authority could be increased, depending on the institutional arrangement selected, to cover budget control and organizational control over the existing systems.

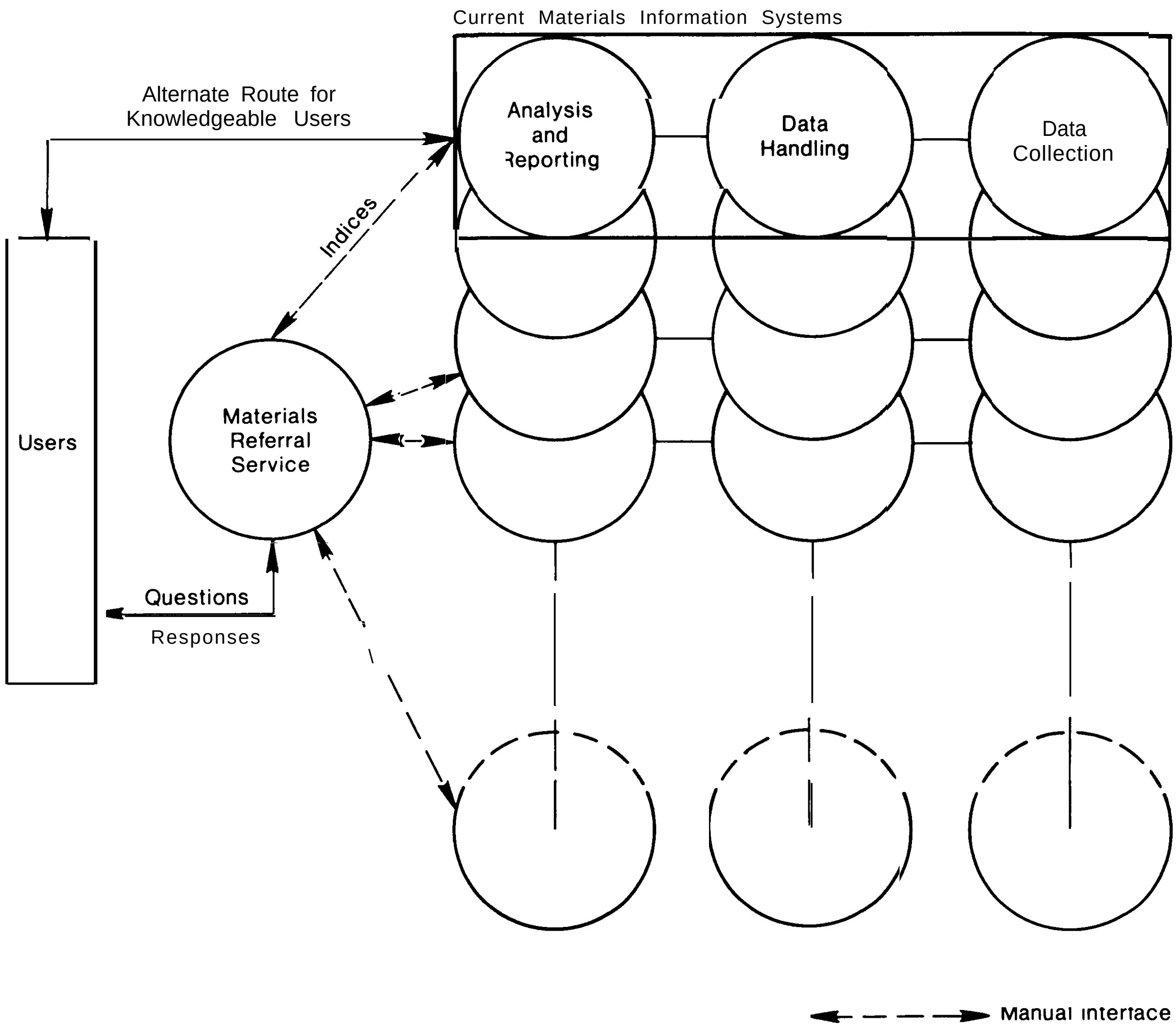
The intent of approach B is to utilize, and upgrade as necessary, the existing information systems to provide the functional requirements. However, the functional requirements do not have to be used initially, and additional functions may be determined in the future. This approach would establish an intermediate set of functional requirements, ensuring that the final set was not precluded in any way. For example, the functional requirements dealing with basic supply and utilization could be initially limited to domestic data, and later expanded to international data as it became more available. The existing systems would be upgraded to handle these requirements in the manner required, but they would be built to allow for expansion to include international data and disaggregated data at lower levels when the data was available. In this manner, the decision to proceed toward implementing the integrated capabilities could be reevaluated in the light of implementation experience, modifying plans based on interactions with the users and reexamining the costs/benefits. Once the immediate functional requirements were identified, their implementation could be accomplished in discrete steps so that tangible, useful support would be given to the users as soon as possible, concurrent with the existing materials information systems services.

Similarity, the basic information services delineated early in this chapter could be implemented in a series of steps, some at the outset and others added later. There is great flexibility in approach B; moreover, the final decisions do not have to be made at the outset, Congress could decide which services it would like to see in the first step; the oversight organization could then implement them, monitor their operations, and recommend services to be provided in the second step. Based on that review, some of the services could be discontinued, and new ones established in the third step, etc.

As an example of how approach B might evolve, a sequential three-step implementation of the basic services is described below, Clearly this is illustrative only, and many variations are possible,

a. Step 1: Materials Referral Service (MRS). Step 1 would establish the oversight

Figure V–1. Approach B, Step I—Materials Referral Service



agency to move existing systems in the direction of realizing the integrated capabilities. This agency would establish (1) the materials referral service to make existing information sources and services visible and accessible, and (2) the materials information exchange service o develop a materials thesaurus. data element dictionary, and master directory for establishing standardization throughout the materials community. The materials referral service (MRS) would be a focal point for developing and retaining information on the existing materials data and analytical services, the key people and organizations involved in the materials field, the kinds of information required, and the spectrum of materials problems being addressed. Figure V-1 is a simplified diagram of this step.

The principal responsibility of the MRS would be to respond to requests for ma terials information. Its initial response would be to direct the user to the individual or organization most likely able to provide the answers or develop the required information. Subsequently, MRS could direct the user to a known

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source of the data or advise him that the data does not exist. For complex requests, there could be more than one individual or organization involved in developing the answers. The MRS analyst would work with the user to structure the request into component parts which could be handled by each separate source selected, In addition, the user's analysis of the results, when obtained, could initiate a new request to MRS to identify an expert to assist in interpreting the results.

In support of this principal responsibility, several major activities could be performed by the MRS. It would:

- Create and maintain files on existing information systems, their data bases and analytical services, and key people involved in the materials community. The output of the activity would be a materials master directory;
- Retrieve and produce results from these secondary files in response to user requests;
- Maintain a controlled set of materials keywords as a standard means of identifying primary sources and individuals. The output of this activity would be a materials thesaurus;
- Develop and compile statistical information concerning the types of questions asked, the most frequently referenced data and individuals, and the adequacies of the results as expressed by the users of the service. This feedback to improve the referrals would also prove useful in determining the requirements for steps 2 and 3; and
- Produce a periodic report to the materials community which would list the information contained in existing information systems. This would result in feedback on new developments, additional capabilities in existing organizations or services, and correction of the existing information. The output of this activity would be a materials catalog which would be the principal means of keeping the MRS reference information files updated.

The main activity of the MRS would be to use the secondary information collected in the materials directory to answer user's questions by directing them to the proper source. For example, the question of how much coal was provided in the continental United States in 1974 might be answered directly from a published report, Using the materials directory, a MRS analyst would direct the user to this report. In many instances, the MRS analyst would have to provide assistance to users to ensure that their questions are processed as intended. For example, if a question on 1974 domestic coal production were asked in January 1975, the MRS analyst would not yet have had the pertinent published report and would have directed the user to consult various periodic reports for each of the States and to add the production figures himself. If the December 1974 report were not published and the figures for that month were available only in a particular office, the MRS analyst would have directed the user to call an individual to obtain them. A record of all requests and questions, whether answered or not, would be kept for use in analyzing MRS responsiveness. If possible, a feedback loop would be established to begin to evaluate whether the user was satisfied. A feedback from the cited references would also be useful to assist in determining whether they could respond adequately.

The MRS would monitor its interactions with users to determine:

- The kinds of questions asked most frequently,
- The staff skills required to obtain satisfactory answers to user queries,
- The types of questions which remained unanswered,
- The specific materials most frequently referenced,
- The distribution of queries across the

user groups (executive, legislative, general public), and

- The existing agencies or facilities with unique competence or superior data sources in various fields relating to materials,

This information would be used to determine primary data needed for the MRS reference files. Once users found the required source of information, they would return directly to that source as needed. However, new users with the same questions would use the MRS. as would past users for new queries.

The MRS might evolve through several stages of automation as its data files grew and the number of users and materials sources increased. First, a manual operation could be used to collect all published indexes to materials data, qualified people, published thesauri, and keyword lists to assist in providing the references needed, Analysts answering telephone inquiries might work mostly from printed reference sources, such as lists. technical publications and reports, and abstracts, but would also draw on their knowledge of the materials field. Each MRS analyst would be responsible for maintaining awareness of publications, existing data, and experts in his area of interest.

A master directory to materials data sources would serve as the principal new reference tool for the MRS. Producing this directory, promulgating its use, and keeping track of its usefulness to MRS users would be a continu - ing MRS responsibility. The master directory might be developed using off-line batch operations at an established computer center with text processing capabilities. The directory would be published and distributed throughout the materials community for feedback to assist in upgrading existing entries and adding new sources of data and expertise. The master directory would provide the following information:

- The various data sources in existence,
- Their locations.
- The people who maintain them and control access to them.
- How they can be contacted,
- The form in which information derived from these data sources is disseminated.
- The currency of the data.
- The reliability y of the data, and
- Any special analytical functions performed on the data at the particular location.

In compiling this directory, use would be made of the many indexes to data sources already in existence, such as the Federal Energy Administration's index of energy materials. Information already available in existing directories and indexes would be incorporated in the MRS materials directory. Other information would be obtained by new surveys. This compilation of data sources would be followed by an analysis to identify data duplications, omissions. and terminological differences.

It should be noted that duplication of data or data resources is not always undesirable in information systems; it can be used to advantage in maintaining validity and accuracy (through cross-checking) and also in providing alternative access to data.

Following compilation and analysis. the information in the master directory would be formatted to meet the requirements of MRS users, with uniform terminology and cross-references for specific materials (e. g., aluminum), classes of materials (e. g., nonferrous metals), and phases in the materials cycle (e.g., extraction, recycling). Careful control would have to be exercised over any changes to terminology and arrangement: without such control the usefulness of the directory would diminish rapidly. This formatting could be handled manually or with computer support, using time available at an existing computer facility,

The types of activities involved in assembling a master directory also constitute the first phase in the development of a materials thesaurus to establish a uniform vocabulary for the materials community. The usefulness of the thesaurus would be enhanced if the data sources and terminology used by trade associations, private industry, and the universities were reflected in its compilation. The analysts in MRS would consolidate separately published thesauri and keyword lists as a materials thesaurus. This would be published for use in the materials community, with periodic revisions planned.

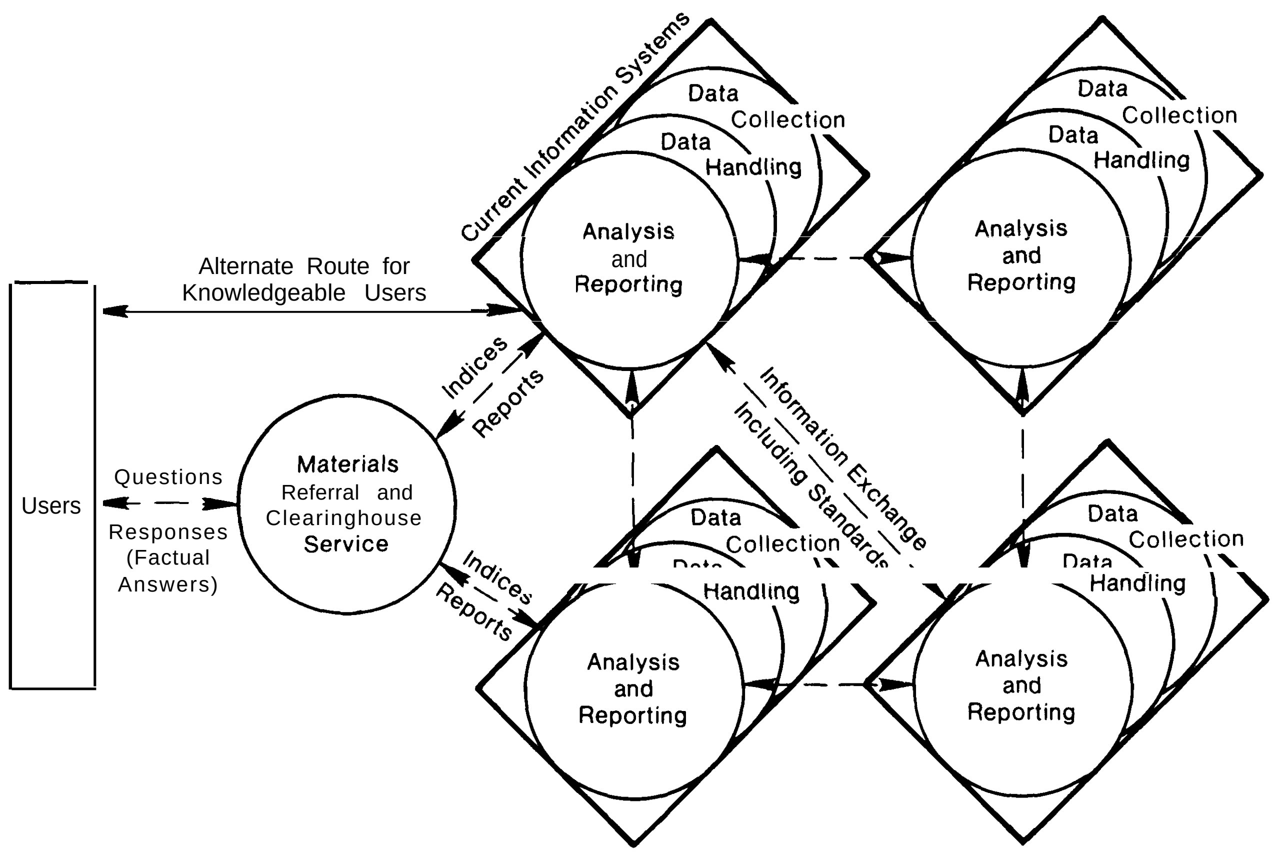
The MRS analysts would then be working from their two major sources, the master directory and the materials thesaurus supported by the MRS internal data on queries and references cited. At this point, after more information on data sources had become available in the MRS and secondary data collection had taken place, it might become necessary to compile a dictionary of primary data elements occurring in the many data bases maintained by the existing institutional agencies. The dictionary would include the names of the data elements, the larger context in which they are used, their format, source, validity, and status. The data element dictionary on the data processing level would be linked to the materials thesaurus on the human level.

As reliance on the MRS grew, it is likely that more complex queries would be asked and more sophisticated responses required. The master directory would be updated with additional references as more critical materials were added to the list to be covered. Updating the indexes and bibliographic references would continue by processing changes and additions to the secondary files at a computer service center. The retrieval of these references and production of responses, however, could then be performed at a video terminal. This would improve response time and allow analysts to browse through the secondary files for more accurate references. The consolidated thesaurus might be available on line to assist in developing more comprehensive searches for the users and in selecting keywords for indexing new material data sources, organizations, and individuals. Statistics on terminology and references would be produced automatically as a byproduct of the terminal sessions, There would still be a requirement, however, to have the users and referenced individuals feed back their evaluation of the query results.

At this stage the computer would likely be filling a major role in the operation of the MRS, relieving the MRS staff of many laborious tasks and allowing them to handle more thorough searches of voluminous files with shorter response time, It is in this stage of development that the MRS would be somewhat different from the referral capabilities available within existing Federal information systems. The current referral services can direct the requester to an organization or an individual who will have data of a generic type, such as for petroleum; it might even be able to tell him that FEA has production statistics on petroleum. However, the MRS would be able to tell the requester that FEA has an automated data base on petroleum called PRS which contains the specific data element such as producer, name, location, amount refined, amount stored, etc. It is this capability that would make the materials referral service so beneficial to all users.

b. Step z: Clearinghouse Service and Materials Information Exchange Service. Step 2 in this illustrative sequence would establish the clearinghouse service to index and abstract needed and unavailable materials information and to provide dissemination capabilities to users. The development of the materials information exchange service would continue. The materials thesaurus, data element dictionary, and master directory would be needed for both the materials referral service and clearinghouse service to identify the sources of materials information, the types of data contained in those sources, and the vocabulary to be used in indexing this information for search and retrieval. A secondary use would be to encourage their adoption throughout the Federal system and the private

Figure V–2. Approach B, Step 2—Clearinghouse and Materials Information Exchange Services



sector to facilitate data exchange and usage. The standardization of data formats and data handling procedures is a formidable and lengthy task; it need not be completed before proceeding to step 3. Figure V–2 is a simplified block diagram of this step.

The clearinghouse service is an extension of the materials referral service. In addition to keeping indexesor references to existing sources of materials information and analytical sources, it would collect, abstract, and index primary materials data in order to be responsive to user requests. The use of this service might be restricted to those reports of interest to policy makers which were not available in other retrievable information systems. For example, there are indications that reports developed in response to one-time requests, serial publications, and R&D reports do not appear in searchable data files or take too long to get there. The clearinghouse service could be designed to address this problem immediately. A knowledgeable staff member could review the report and prepare a special bibliographic record (reference). possibly accompanied by a description or abstract which would serve as a pointer or index to the full results. In this manner, the clearinghouse staff members could attempt to answer simple factual questions by providing the user with data, the abstract or the full publication, acting as the connection between the user and the source. The following activities would be added to those covered under materials referral service:

- An indexing and abstracting activity for materials information not currently covered by available commercial or Government services, and

- The development and maintenance of a materials information dissemination activity,

Another activity of the clearinghouse service would be to keep track of what specific data were located to answer a user's question, These results would aid in determining the appropriate aggregation level for the data being collected.

There are various stages of development or sophistication that the clearinghouse service might attain. Each would offer policy makers varying degrees of responsiveness. In stage 1, the staff could handle the abstracting, indexing, and searching activities using the computer, as in the advanced stage of MRS. It could have computer support in organizing and listing the references, abstracts, and keywords (thesaurus), as well as in searching for and retrieving the correct reference or abstract for display on a video terminal. With the increased volume of references and the addition of abstracts, the computer might be essential to maintain responsiveness. Preparation of the references and abstracts could be a manual operation. Later, an interactive, online indexing and abstracting capability could be added to the the basic retrieval and production function of the MRS. This capability would assist the staff analyst in preparing changes and additions to the secondary files, allowing him to handle a larger volume more efficiently. In addition. the analyst could be able to use the video terminal to gain access to other online materials bibliographic/abstract data bases—such as the National Technical Information Service (NTIS), Defense Documentation Center (DDC), and Smithsonian Scientific Information Exchange (SSIE)-either by subscription or by permission. The analyst could then browse through data bases to see what appropriate information was available for reference purposes. (The National Energy Information Center has access to 30 different energy-related data bases which can be searched by terminal,) In this manner, the clearinghouse analyst would have access to all major reference/abstract sources pertinent to materials. Use of the computer could allow him to search these sources quickly and thoroughly for references in answer to a user's question.

Step 2 might also address the problem of data compatibility among components of the existing information systems. Standardized data attributes and terminology relating to specific classes of materials could be imposed in order to improve data flow and communication among the many organizations collecting, disseminating. and analyzing materials information. This discipline would be imposed by directives by the oversight organization and monitored to ensure compliance. Standardization could involve some or all of the following:

- Data descriptions,
- Data formats,
- Classification designations,
- Data attributes,
- Data collection techniques,
- Technical terminology, and
- Units of measure.

To enhance compatibility, inconsistencies would also have to be resolved with respect to insufficient knowledge of data accuracy and validity, The data elements dictionary and the materials thesaurus (started in step 1) would be the basic instruments for recording the varying data standards within the existing system. Analysis of the uses would yield criteria for determining the appropriate scope of the standardization effort. Once the standards have been established, all agencies responsible for collection, management, analysis, or output of materials information would be required to adhere to them.

Two major considerations apply to such a standardization effort, increasing compatibility while minimizing disruption, Theoretically, one could require that scientists and technicians in the field adopt a new technical vocabulary, as well as new methods of data collecting and reporting. Such an approach, however, would likely be needlessly disruptive. Every effort would be made to resolve ambiguities and inconsistencies through the judicious use of computerized translation or conversion programs. Indeed, just recording the different uses of the same data among the components of existing systems would go a long way toward helping users and managers of materials information.

The standardization effort envisioned would require an implementation plan that would have to cover:

- Information collection.
- Definition and review,
- Development and installation,
- Operations and maintenance.
- Feedback and modification, and
- Audit and control.

A multidisciplined team, preferably including representation from the private sector, might be set up to develop specific procedures and an overall plan and organization to ensure orderly development. Information regarding requirements, current exchange problems, current data flow, and current standards and conventions would have to be collected and analyzed. Priorities would then be set, and an interactive definition and review cycle begun. Organization impacts would be assessed and the necessary organizational support acquired. In a similar undertaking the Canadian Department of Energy, Mines, and Resources began a project to identify sources of geoscience data (i.e., original observations and measurements). Because of the large number of documents involved, their wide physical distribution, and heterogeneous organization and reporting structures, a decentralized, cooperative approach was adopted. Canadian geoscience agencies were asked to voluntarily index documents published or held by each agency, with the results to be incorporated into a computer-based index by the Canada Center for Geoscience Data. Over 40,000 titles from 10 agencies have been indexed in detail and consolidated into the Canadian Index to Geoscience Data, Consistency and vocabulary control are maintained through a thesaurus of over 5,000 geology keywords under direction of a committee of the contributing agencies. After years of work, good coverage now exists for Ontario, Saskatchewan, Quebec, Newfoundland, Yukon, and Northwest Territories. Completion of Federal and Provincial Government documents is expected to take about 4 more years, It should be emphasized that this effort involved only the data for resources.

Many activities normally carried out by the referral and clearinghouse services would derive benefits from the improved compatibility introduced into the information system. The staff could use video or hard-copy terminals to review pertinent sections of the materials thesaurus and data element dictionary (both of which would have been standardized and cross-referenced appropriately), They could also review the master directory, as well as other secondary files created by the referral and clearinghouse services. This, in turn, could provide faster and more comprehensive searches for users. Dissemination of materials information could then be carried out systematically on the basis of user profiles submitted to the MRS specifically for that purpose. Regular (batch) searches could be made on new primary and secondary materials data and the results forwarded to users in hard-copy form.

The enhanced information capabilities of both the referral and clearinghouse services could also enable the staff to produce and update special indexes to its growing data sources. Very likely these indexes would be specifically designed to allow quick answers to frequently asked questions. With the growing emphasis on in-house information processing capability, there might well be an increasing need for information specialists who could perform and direct the indexing and abstracting tasks essential to the whole process of transforming and transferring information. As the volume of incoming materials data increased, the information specialists would implement automatic indexing procedures coupled with automated (batch or online) retrieval. Similar procedures have been implemented in existing systems, but their effectiveness depends greatly on control over vocabulary; improved effectiveness could be achieved through the standardized materials thesaurus. Effectiveness would also depend greatly on the competence of the designers who would approximate complex semantic relationships through very simple data processing techniques. Fortunately, considerable experience has already been gained with retrieval methods of this kind that have been used successfully in systems dealing with scientific and technical information. Furthermore, this simple (essentially unformatted) approach to text retrieval is not incompatible with a natural English language query,

c. **Step 3: Summary Data Base and Statistical Services.** Step 3 in the illustrative sequence would establish the summary data base service. Pertinent data, as identified through experience with users in steps 1 and 2, might be requested from each information system and placed into a centralized data base. The existing systems would have to convert the data to the prescribed format and send it to the oversight organization on a periodic basis to keep it current. Statistical services could be added to supplement the statistics prepared by the existing information systems. As envisioned they would be aimed at providing summary information to the Congress and the public on the status of critical materials. The centralized data base would also be available to support specific analyses by an authorized user, Congress, the executive branch, and the public.

Having established the materials referral service, expanded it to include a clearinghouse service, and introduced a level of standardization procedures, the existing services might then be further augmented through aggregation of data and additional data processing support. Major attention in this third step is seen to be centered on access to analytical tools. Whereas the efforts of steps 1 and 2 would have concentrated on identifying and analyzing data sources, step 3 would provide a summary data base comprising the inventory and economics data on the most frequently referenced critical materials. With this summary data, users could apply their own analytical capabilities to study the effects of policy alternatives. The summary data base would be built from data currently available within existing information systems, Having established data compatibility, chances of misuse or misrepresentation of data collected for the summary data base would be reduced, and new opportunities for effective interagency data exchange would be created. Improved data processing support would allow users to take full advantage of these opportunities, Figure V–3 is a simplified diagram of this step,

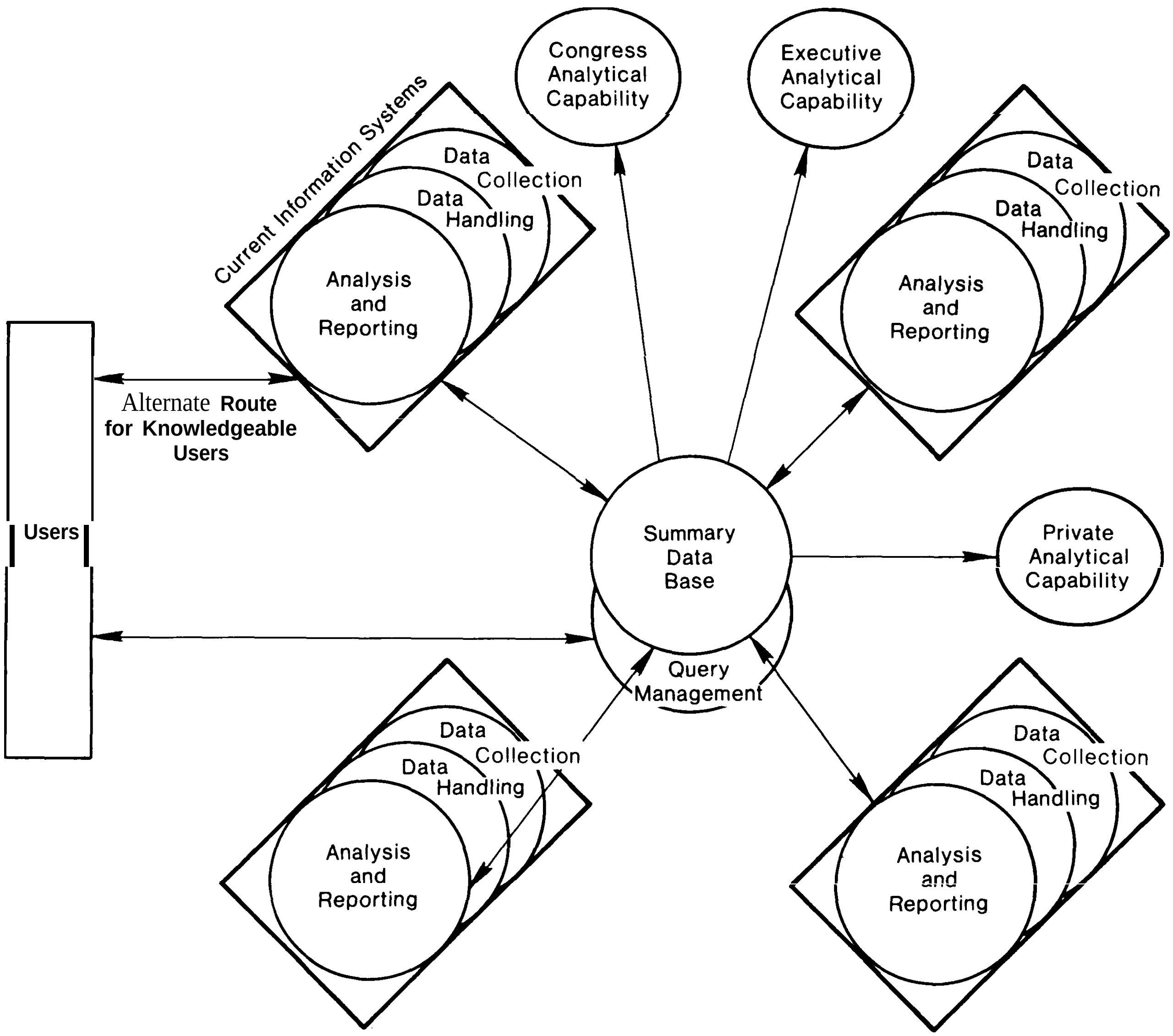
The materials referral service and clearinghouse service described in steps 1 and 2 would be expanded to provide a full query management service. The summary data bank and the secondary indexes would be available for analytical use by executive, congressional, or private organizations. Alternatively, an analytical capability, in the form of support tools such as statistical analysis packages, might be developed as part of the center's own organization.

Step 3 thus provides for the following additional services:

- Query management service,
- Summary data-base service,
- Statistical services and optional modeling services, and
- Data processing support services,

The query management service would be an extension of the clearinghouse service to enable it to handle complex user requests for the

Figure V–3. Approach B, Step &Summary Data Base and Statistical Services



summary data base service and statistical service. A staff of specialists knowledgeable in economics and materials-related areas would be needed to assist the staff information analysts in analyzing and answering user requests.

Based on the experience gained in monitoring the operation of steps 1 and 2, the oversight organization, having overall responsibility for accomplishing the upgrading of existing systems, would know the most frequently asked questions, referenced sources, levels of data aggregation, other user requirements, and user satisfaction with the referenced sources. Were a decision made to proceed to step 3. the oversight organization could then use this information to structure the summary data base that would be operated under its control, Participating institutions would be directed to send specified data in specified formats for inclusion in this data base. They would also be charged to periodically update the data by forwarding changes. As the illustrative evolution of approach 2 is here envisioned, this should not be a significant burden on the agencies since they would have information management systems with the capability to produce special files. If they did not, a program would have to be developed to accomplish the conversion.

The summary data base is not intended to hold detailed data. Provisions would have to be made to prevent it from growing too large. Explicit purging provisions could be established to ensure that obsolete or unused data were removed from the data base. In fact, the design of this summary data base would involve a trade-off between too much data at the summary level and too many accesses to the detailed data bases. Since no practical summary data base could contain all the data that a policy maker might need, continued access to the existing individual Federal information systems would still be required.

In terms of the staffing required to operate the illustrative summary data base and statistical services, commodity specialists, subject matter analysts, economists, and information analysts would work together to produce both periodic and special reports requested by users. Query management specialists would work with these specialists to develop the form of the report, the resources required, and the schedule for completion, Depending on the user, there might be a fee for these services. If existing procedures or models were available within the existing information systems to perform the required processing in support of the analysis, then the analyst would schedule the processing. He would check to see whether the correct data were available for the run. If it were not, he would obtain the needed data from the summary data base or the existing information source, whichever was appropriate, and forward it to the organization that had the model. This transfer of data would be accomplished via hard copy or computer media (magnetic tape, card deck). If new procedures or models were needed, the analyst would see what resources were needed to develop these items. He might then schedule this activity through direct contact with either the private sector or Government institutions. It is also possible that standard, available statistical packages or modeling languages would allow the MRS analyst to develop the tool himself and then process the appropriate data.

The data processing services, to support these activities, would involve the operation and maintenance of all digital computing equipment, keyboarding devices, terminals, and other media devices (microfiche, transmission equipment, graphics equipment) needed to support the other services described. This responsibility would include the following software used by the analysts and programmers:

- Operating system,
- Data base system,
- Data communications system,
- High-level programming languages,
- Utility support package,
- Scientific and statistical support packages,
- Modeling languages (optional),
- Materials and economic models (optional),
- Text processing system, and
- Online interactive terminal languages.

Detailed statistics would be obtained for all activities. Gathering these statistics would likely require little additional effort by the staff since the data would be generated and collected as a byproduct of the various processing activities and stored as part of the summary data base, Management could then view specific items by request. Exceptional and unusual activities in any part of the system would be noted and reported immediately to the data and/or security manager, The routines used for materials data analysis would also be used to support internal management and security.

In summary, the enhanced services accomplished through approach B would provide several benefits for users and participating agencies:

- Existing agencies would find it easier to obtain needed data from other agencies using the new services to facilitate the exchange.
- Users in Congress and the private sector would have their questions answered more promptly and would have broader control over the form in which the answers were presented. For example, it would be feasible to rapidly generate plots of data developed through the use of analytical models. Such plots or graphs could be transmitted in hard-copy form to the user. This offers more than just another way of viewing results; it constitutes an opportunity to reduce significantly the physical bulk of responses offered to policy makers. Rather than merely produce large volumes of data. the new capability would provide information (in the form of trends, extreme-value reports, summaries, graphic comparisons, etc.).
- The improved information services would make it possible to alert users immediately to the existence of new data and information through an expanded information dissemination service.
- In processing queries, the referral staff would be able to engage in a dialog with both the user (via telephone) and the center's data bases (via computer and online terminal). Responses obtained from the online system could be verified or alternatives discussed while the user was still on the telephone,
- In some cases, it might be able to process an entire complex query in-house, This could include running a simulation of one or more analytical models on aggregated data available in the central data base.
- Many of the standard analytical tools would be available within the center, However, analytical capability would remain in the agencies, with a small group of experts also at the center. The agencies would honor requests for aggregated data from the oversight organization by transmitting the data to the summary data base in magnetic or punched-card form. In this way, the center would be able to serve as a data storage and analysis center for the most critical materials data in aggregated form. Since it would not normally carry out any primary data collection activities, it would rely on the agencies to supply current and valid data,
- The center would provide query management capability, including the capability to assess bibliographic and abstract data available in agencies' data bases. Information specialists working from video terminals could accomplish this by first determining what data would be needed for a particular problem, then querying the data directory to determine the 1ocation of the desired data, and finally obtaining access to the data itself via a telephone or correspondence, depending on its urgency,
- The MRS could handle "what if" type queries. These queries might explore the impact of proposed legislative or executive actions in particular aspects of materials management. This would normally require selection and use of a suitable simulation model (by the agency that maintained the particular model). The center staff would play a role in selecting the appropriate model, making the user aware of its assumptions, and interpreting the results for him. (Alternatively. the center could suggest to the user one or more experts who could assist him in interpreting the results.) Depending on how it might be implemented, the output resulting from the simulation exercise might not be forwarded to the user at all; instead, the center staff could act as interpreters of the technical data for the users they serve, Operating in this manner, the center staff would assume

responsibility for determining the user's intent, processing whatever questions were implicit in his intent, coordinating the results, and communicating the final answers to the users,

3. Approach C: New Information System

Approach C is based on the development of a new materials information system designed and built from the top-down. The design would begin with a set of carefully defined requirements, the results of a design requirements study, and would be based on use of up-to-date technology. The desired integrated capabilities would be realized without undue regard to existing information systems. The existing information systems would influence the implementation planning in that parallel operation and phaseover of capabilities would have to be addressed, but the new program development plan would be largely free from the constraints of existing operating systems.

It should be emphasized that the new "system" implied by approach C does not imply total centralization of data and processing functions. Rather, what is envisioned is a distributed system operating in the various agencies as well as in a newly established information center. However, the authority for directing this approach would be legislated or assigned by executive order to an existing or new authority. This authority would provide greater control over the existing institutional materials information systems than in approaches A and B. Accordingly, this approach represents a more significant break with the past and, as such, implies greater changes to current activities and larger initial outlay of funds. The base requirements of this approach would be accomplished at the price of one-time development costs and possible disruption to ongoing activities during phaseover.

Rarely does the opportunity arise to exercise hindsight in system design. Since this approach, in effect, is to "start over, " it provides just that opportunity and should be evaluated as a candidate option for achieving the improved capabilities. As presented here, approach C would likely take longer to implement than the other approaches, However, should short-range capabilities be needed, there is a measure of flexibility in the approach to attain results earlier.

a. Approach C Development. Approach C would involve four steps:

- Step I—Define the program plans, controls, and measurement functions and organization with which to manage the system's orderly development and implementation. The organization would manage the numerous project tasks and provide continuity throughout the project life cycle. It would provide a central control to ensure that the enhanced array of information services being developed would:

  —Support the legislated mission;
  —Be flexible enough to respond to impacts of external sources and events;
  —Maintain data security, integrity, and timeliness;
  —Maintain uniform data base and coding structures, compatible software systems and telecommunications; and
  —Be within the resource and cost limitations imposed,

  The organization would assume responsibilities for overall thesaurus control and would examine the applicability of existing thesauri for this purpose.

- Step 2—With the information plans, controls, and measurements organization in place, the detailed requirements for the integrated facilities would be defined, based on the studies completed to date and a detailed survey of all users. When the required output and processes to achieve it were specified, an inventory of data sources would be prepared to determine what data were usable and what new data must be collected to support the data base. The data requirements specified during this activity would be used to begin collecting pertinent data while the "system" development process continued.

- Step 3—The requirements definition would be used to develop design and performance requirements. Hardware and soft ware, including a complete data management system, would be selected and procured based on the requirements and system design, Trade-offs would be analyzed to determine the plan for implementation of the design, such as where to start and how to phase over. Factors such as cost and disruption would be weighed against the need for function in deriving this plan. Part of this planning would involve analyzing requirements against off-the-shelf software products such as data base/data communications software,
- Step 4—After hardware and software components were selected, the initial applications could be developed and tested, and the operation could begin, Parallel with this activity, staffing would begin and training, procedures, and operations would be developed. In initial and subsequent application developments. current data bases would be examined to determine applicability to the new system environment.

Implementation of the integrated capabilities would be accomplished in phases, determined by priorities in the plan developed by the control group established in step 1. Therefore, step 4 might be repeated several times. Similarly, perhaps less frequently, steps 2 and 3 might also have to be repeated. The implementation plan would thus have to be flexible enough to respond to unforeseen circumstances during the development cycle, such as the requirements changing as major changes occurred in the system's intended operating environment. The planning group would have to control the project and maintain measurements and audits throughout the development cycle, so that change could be accommodated and with minimum impact on schedule.

As the evolution of approach C might be accomplished, the need to attain short-range results might take the form of installing an MRS (as described in approach B) between steps 1 and 2 of this approach. at the point where thesaurus and data inventories were identified. A variation of this approach might be directed at implementation of all of the integrated capabilities for a single material, instead of all or even one class of materials. Experience gained from providing support for the one material could then be applied to adding coverage for the additional materials. This procedure would be less disruptive and less costly, as the reiterations would be simpler to accomplish for one material. Still another variation might result in the establishment of an analysis group quite early in the development cycle. This group could begin to correlate supply and demand data by using whatever data were available for rough estimates. Their experiences could then be incorporated into the orderly planning cycle. Approach C provides great flexibility in building the new information services on a "learn and go" basis.

b. The Changing Relationship of User Needs and Capabilities. Approach C would provide a complete, detailed distributed data base to meet user needs. If a data item were needed, the data would be made available either from a reliable source or by assigning a qualified organization to collect it,. Analytical functional requirements not already available would either be developed as needed, Procedures to new functional requirements that may be only imperfectly specified now would be provided; for example, ways to accommodate information on materials selection (See appendix A,)

Any information "system" is of course designed and implemented to attain a definite set of goals, and after some period of operation it is frequently found to be deficient for new objectives, This same pitfall awaits the "system" that might evolve from this approach; care must be taken to avoid it, One tactic is to devote a large portion of the total design effort to the definition of functional requirements. While experience shows that this increased emphasis is desirable, it will not necessarily avoid all the pitfalls, The fact is that functional and performance requirements change over time. It is probable, therefore, that significant changes will have taken place between the time of the requirements definition and the time the system processes its first data.

What is needed, then, is an adaptive approach which will enable users to respond to change. The degree to which such an approach may be realized has bearing on the weight to be placed on the costs and disruption incurred in developing it. If a one-time cost and a one-time disruption can eliminate future repetitive expenditures and disruptions of operations, then they may well be justified. A "system" designed to recognize the requirement for change and to enhance the ability of incorporating new functions to meet change has certain characteristics which differentiate it from other systems. Such an adaptive system may be considered as having two components—a data processing component and an evolution component (see figure V–4). The data processing component would offer standard production data processing to its user; the user would make a request for processing and receive results. This data processing component would be preconditioned for the requests based on the requirements definition. A discussion of the kind of structure currently envisioned for this component is presented in the next section. The other evolution component would be totally committed to increasing the responsiveness of the system to change and crises. The work performed by the evolution component can be grouped as follows:

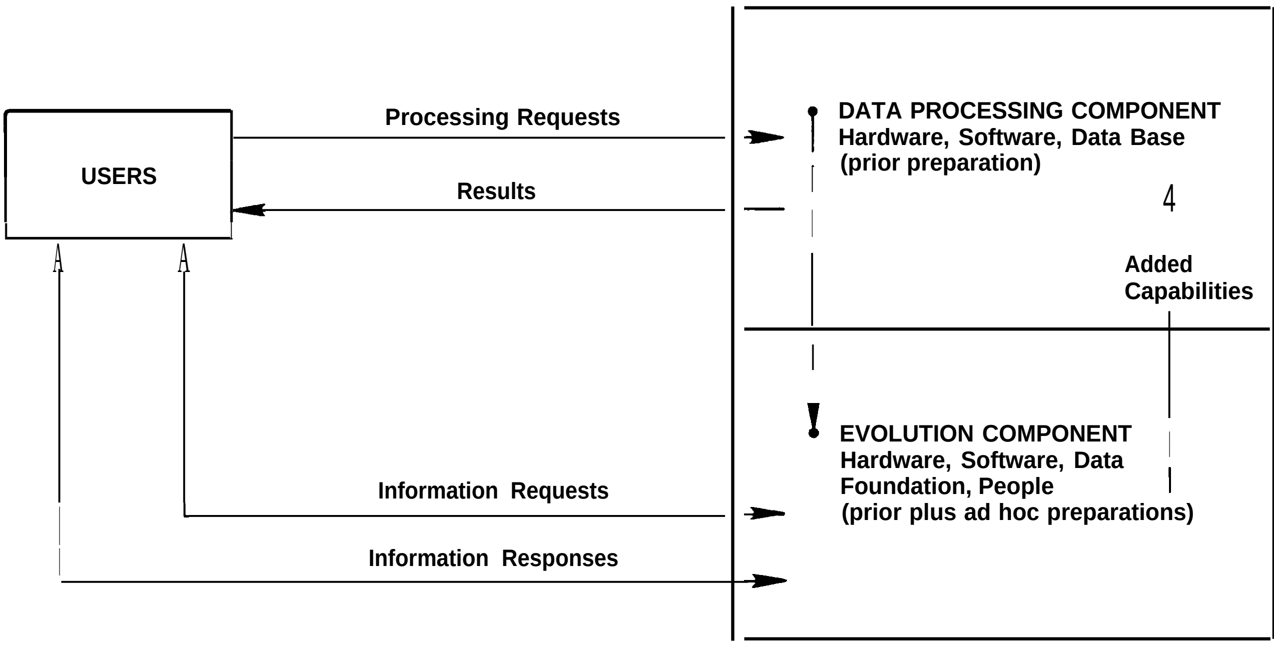
- Formal Semantic Dictionaries.—Within the evolution components, dictionaries would be compiled and maintained containing definitions of terms and concepts appropriate to the new system and its community of users.
- Information Clearinghouse,—The system would serve as a clearinghouse for exchange of information about itself.
- Program and Data Archives.—In addition to program documentation, programs would be collected and stored in libraries by the system.
- Readiness Management.—Efforts would be made to ensure that the permanently assigned staff is ready when a new requirement emerges.

c. Concept of Operation. In approach C, an information center would be used as the primary interface for policy makers seeking information. The materials information center would contain data, analytical tools, and resources sufficient to respond directly to many of the requests of policy makers. In addition, the information center would function as its own referral service to enable it to gather information from other points within the system or to levy new requirements where appropriate.

The other points in the system would be the existing institutions and agencies which currently process materials information. Their missions would not necessarily change, but might be realigned to avoid duplication or expanded to implement new functions, Existing institutions would continue to collect data and process it in support of their own missions. They would have the added responsibility of responding to requirements levied by the information center; in turn, they would benefit by being able to make use of the center and its capabilities,

The imposition of compatible information systems would offer a high degree of physical and logical data interchangeability. Data files could be moved from one location to another, and data access for one location could be triggered by another. This would facilitate data communication for access to and correlation of data from multiple stores across different agencies. Note that the capability for interchange would greatly increase the need for

Figure V-4. Adaptive System



adequate data security controls. Before such standards were imposed. the increased costs that would arise if agencies either replaced their current systems or made parts of them compatible with the new system would have to be carefully considered.

There is an opportunity when developing a new "system" to establish standardization among all operating locations. Since these operating locations have separate missions and are primarily responsible for supporting separate organizations. there will likely be a tendency over several years for redundancy, inconsistency, and ambiguity to creep in. Data redundancy—practically unavoidable and sometimes beneficial-could cause problems in updating. If redundant data are all updated whenever a single data item is updated. a penalty must be paid in performance. More important, there is normally a lack of awareness of the existence of the redundant data. During the updating process, the new system should be capable of managing redundant data so that an update transaction to one data item will trigger subsequent updates of redundant data wherever it exists within the system. This is a large task, but one which could be accomplished by careful file structuring or by periodically scheduled batch updating.

Inconsistency presents a similar situation as redundancy except that here actual stored values at different locations differ. One method of dealing with this problem would be to bring apparent inconsistencies to the attention of the information center to be resolved as appropriate. Ambiguity is the most significant obstacle to direct data interchange (machine - to-machine). Different meanings for like-named data elements are prevalent and difficult to discover in existing data bases. In addition to format, the meaning of the data must be understood by the particular organiza - tion in order to effectively process its data, but the meaning is not always apparent to outside organizations. those not possessing a day-to-day working knowledge of the data. The semantics of the data differ among data bases, programs, and personnel at various locations. Combining these factors would be essential to obtaining interpreted and correct results.

When the information center had determined that the information required to respond to a query existed within the system but in several different locations, it would consider a search strategy to gather the data. Normally, with any complex search involving multiple data bases there would be multiple paths which could be followed to get to desired data. Selection of a search strategy is defined as the choice of a path by the human information specialist, using the computer to assist but not to make the selection, Multiplicity of paths and the strategy options which result occur primarily because of redundancy. Redundant data permits correlation from different data bases. It offers the "glue" by which records are attached to other records, to extend the scope of linked data across data bases. Therefore, although redundancy creates problems for updating, it permits increased search capability,

As envisioned, the tactics of information searching would be the responsibility of the individual operating agencies themselves. That is, once the search strategy had been chosen by the information center, the involved organizations would be asked to conduct the searches. This approach offers advantages over that of direct access to the data to overcome ambiguity problems. Reliance on the personnel in those organizations using their own programs to search their data bases would likely yield more accurate and better interpreted results. Some searching might be done in parallel. The information center could initiate operations at multiple locations at one time. It might also be necessary, in some cases, to retrieve data from one organization's data base prior to directing that a search be performed at another location in another organization's data base.

The concept envisioned here would thus be a network operation in which large files would not be transferred across communications lines and direct searching in another organization's data base would be avoided. Rather, emphasis would be on individual agencies performing searches as requested. Output available to the information center, would be of low volume since the data would have been analyzed, evaluated, and interpreted by the agency's personnel. Conversational interaction of the decisionmaker and the information processing system is seen to be a key feature of approach C.

d. Information Center Functional Components. The information center is envisioned to encompass the following services:

- Query management,
- Materials analysis management,
- Data base management,
- Data collection management, and
- Clearinghouse and referral management.

The center would have a capability for infrequent ad hoc queries. Routing and periodic reports could be planned, controlled, or produced as needed. This is one aspect of query management. Short response time for immediate action queries, however, represents another requirement for this system, Whenever possible, the query specialists would have direct access to data and /or knowledge. This data would be dynamically maintained in response to changing situations. If unable to respond using the information center, the query specialist would be able to establish a task force of experts, using the online indexes to find and contact the right people and data to respond to the query or world situation.

In addition to using existing models, improved models to forecast supply and demand of various materials classes and to compute first and second order effects of alternative materials policies would be developed. A complete statistical, analytical, online system capability would be available for use by the analysts to verify the data collected, analyze the trends, support the periodic reports, and respond to the ad hoc queries, It is not anticipated that the analytical and forecasting services provided by the center would necessarily obviate the need for similar capabilities in major departments or agencies, Congress, or the private sector. The existence of independent analytical capabilities supporting decisionmakers in all such groups but drawing data and seeking the assistance from the center would be quite compatible with this approach.

The information center would contain its own data management function which would be used to define, create, maintain, modify, and retrieve data from data bases. Data can be lost, stolen, altered, distorted, and destroyed, The particular data to be maintained at the information center, as opposed to that held by other agencies, would initially be determined in the requirements analysis and would be constantly altered as needs evolved during operation. Its management must be planned, budgeted, and controlled to ensure the availability, integrity, and security of the data to both the sources and users,

The data collection requirements for the information center would be determined by the extensive study that would precede the design and development of the information "system". The means of collecting data are many-questionnaires, surveys, forms. machine-readable data, (cards, tape, etc.), and online interactive questions and answers. Similarly, the data can be formatted many ways. How this mass of data is collected, validated, and entered into the data bases would be determined in coordination with the data base manager. Data collection would be done by professionals and monitored by statistical validation programs to check the data and to normalize statistical samples.

The clearinghouse and referral management function would provide the following services:

- Development, publication, and maintenance of a materials thesaurus:
- Indexing and abstracting service for all materials information;
- Development and maintenance of a materials information dissemination and publication service; and
- Creation and maintenance of directories of experts and organizations in the many categories in the materials world.

In its full operation the information center would have to address problems of consolidation, summarization, and aggregation of data; many of these could be in detail after the basic information system was operational. In this way these more advanced information processing capabilities could be defined based on actual experience with the information center.

D. COST ESTIMATES

In assessing costs, the way in which the integrated capabilities are achieved is very important. The feasible combinations and permutations within each systems approach as well as within combinations of these approaches (such as A and B) are quite numerous, For example. an information system which applies the basic functions only to timber (forest products/paper class of materials) is easier to implement, less costly. and can be done faster than an information system which applies the same functions to the entire nonfuel minerals class of materials. The former involves principally one material, one institution, one already automated information system and one principal location: the latter involves many institutions (BOM, USGS, BLM. OMPD, Bureau of Census. DIBA, ERDA, GSA), and many manual and partially automated information systems with differing capabilities,

The number of users and the specific purposes served by an information system must also be considered. An information system that collects supply and utilization data to build a comprehensive, current data base to be used for monitoring and identifying potential materials shortages (early warning) is simpler and less expensive than one that collects the same data for use for both early warning and assistance to design engineering, The former might need materials inventory and economic data aggregated only to the regional level.

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whereas the latter might also require detailed materials properties data. An information service with simple statistical support capabilities based on extrapolation of past historical data and summaries is simpler and less costly than one with sophisticated modeling and forecasting support capabilities. The former involves standard programs that are available off-the-shelf and operate on the types of data in current materials data bases; the latter requires developing complicated programs which operate on the types of data in the current materials data bases and on many other exogenous factors, thus requiring additional data collection. As a final example of the influence of the scope of capabilities on cost, an information system that produces such periodic output as summaries and statistical trends on particular materials and that sometimes provides aggregated information upon request is simpler and less expensive than one that performs complicated policy analysis and impact assessments for policy makers.

Cost is also impacted by the implementation time schedule and by any acceleration or deceleration to support changing national, institutional, or materials priorities.

The estimates provided here indicate, to a general degree, the costs of resources in terms of manpower and automation requirements to develop and operate the facilities required. As indicated above, the estimates depend on many variables whose values cannot now be specified. Notwithstanding these recognized limitations, the estimates are useful in developing an appreciation of the relative investments that might be required for the three approaches. Quite clearly, the cost estimates should not be used for any other purpose.

There are four types of costs involved with each of the three approaches:

- Costs for data collection and validation for the selected materials,
- One-time, nonrecurring development costs consisting of personnel to perform requirements definition, design, development, and implementation. These costs include those efforts associated with new services as well as improvements to existing systems.
- Automation costs consisting of purchase and/or lease of necessary facilities to provide computer support, communications support, and special equipment such as plotters, displays, etc. The Government can either purchase these facilities at the outset and amortize the costs over some time period, or lease the facilities and pay the costs on an annual basis or utilize existing facilities by sharing the usage and costs. For purposes of this comparison, these costs will be considered recurring on an annual basis.
- Operational costs consisting of personnel for management and administration, operations, and information system support such as librarians, information system analysts, subject matter specialists, computer operators, programmers, and statisticians, These costs are recurring in that they will be needed for each year of operation. They include those efforts associated with operating the new information services as well as operating the existing information systems.

The cost estimates were based on the following assumptions:

- Man-year cost estimated at $40,000 per year to include salary, benefits, and overhead (facilities, space, supplies, travel, etc.);
- Computer time estimated at $400 per hour;
- Fees from use by private organizations would partially offset recurring costs. However, since such use was not examined during the study, no estimate of these potential revenues is included;
- No inflation factor included; and

- Only the incremental costs, over and above currently planned budgets, have been considered.

With these assumptions, the annual costs, averaged over 5 years, are on the order of:

	Millions of Dollars
Data collection and validation:	
For 5 materials	2
For 50 materials	20
Development, Automation, and Operation:	
Approach A	2
Approach B	17
Approach C	19

As noted, these cost estimates are considered to be rough at best because of the uncertainty in many of the numerous variables. It is conceivable that the estimates could be off perhaps by as much as an order of magnitude (factor of 10), For realistic situations, the estimates are expected to be accurate within a factor of about 5. It is expected that the relative cost ordering of the approaches would remain the same. Approach C appears to contain the greatest potential for cost escalation. The difference between approaches B and C are negligible considering the accuracy involved in the estimates, Approach C is very close to approach B because it was assumed that a high utilization of existing systems would be possible.

The elements of these cost estimates are described in the following subsections.

1. Data Collection Costs

Approaches A and B are premised on the assumption that the existing information systems (including planned improvements underway) form the basis for the required integrated capabilities. Approach C also will use data collected by the existing information systems, although the degree of utilization of existing information systems cannot be accurately estimated at this time. It is this factor that gives approach C the greatest risk for cost escalation, If the existing information systems are not used to any great extent (for example, if new automated support is required to replace existing support), then the collection costs could be greater than discussed here. Maximum usage of existing systems has been assumed. Existing deficiencies which would have to be addressed, such as lack of needed functions or incomplete functions, would be corrected within the existing information systems. Estimation of these costs is tenuous at best because of the difficulty of establishing the incremental cost increases to existing budgets. However, it is likely that the largest part involved will be those associated with completing the collection and validation of the detailed data for the required materials, Assuming that these required materials will be primarily from mineral fuels and nonfuel minerals classes, and that they may number no more than 50 or 60 in total (including both critical and potentially critical), then an estimate of costs can be based on plans of the Minerals Availability System (MAS) of the Bureau of Mines. The 5-year plan of the Bureau of Mines envisions an increase of MAS coverage to 35 minerals at an estimated cost of $29 million, mostly in personnel. It is thus reasonable to conclude that implementing a more aggressive plan to complete the data collection for about 50 to 60 materials might increase this cost to well over $50 million during the 5-year plan period.

Other costs associated with this activity, such as automation support and communications equipment, should be considerably lower since the basic systems already exist. Extending the coverage to more minerals would not necessarily cause a linear increase for each additional mineral, since these support facilities will already exist for the 35 minerals, Some cost increase is likely, however. due to the larger volume of information to be handled, This increase might be on the order of $1 million for additional storage; substantiation of this cost is the Bureau of Labor Statistics cost of $1.2 million for improving one data item, the price of imports/exports.

The Bureau of Census has allotted in the 1977 budget $3.7 million to prepare for taking, compiling, and publishing the censuses of business, transportation, manufacturers, and mineral industries. The budget for both preparation and conduct of the economic census in 1972 over 3 years was $24 million. Applying these cost yardsticks to the other institutions involved (Bureau of Census, Federal Energy Administration, etc.) for 50 materials might yield an average data collection cost increment over 5 years on the order of $2o million to bring the needed data to the point that it was complete and validated. For five materials we have assumed that these costs are assumed to vary proportionally, i.e., $2 million, Some experts believe, however, that a $4 to $5 million estimate is more realistic.

These data collection costs are applicable to all three approaches. The development, automat ion, and operation costs, however, vary with each approach.

2. Approach A: Development, Automation, and Operation Costs

While the major cost increment in this approach would be for the data collection previously discussed, the increased demand by users to process this data, coupled with increased requirements for processing and analysis support to provide improved services from existing referral and clearinghouse capabilities would increase the development costs of the agencies. These increased costs are estimated to be on the order of $2 million annually over the 5-year period. The operational cost increases are particularly difficult to assess since the present personnel may be able to handle all or a portion of the additional workload of new tasks. In the absence of better information, this assumption was made here; no additional cost for operations is included.

In summary, approach A would involve additional annual costs, over the 5-year plan, on the order of $2 million to $2o million to complete the collection and validation of needed data, and added annual development **costs** on the order of $2 million. These estimates are based on the assumption that the existing information systems are used and the additional operating costs of new services are absorbed within existing agency manpower budgets,

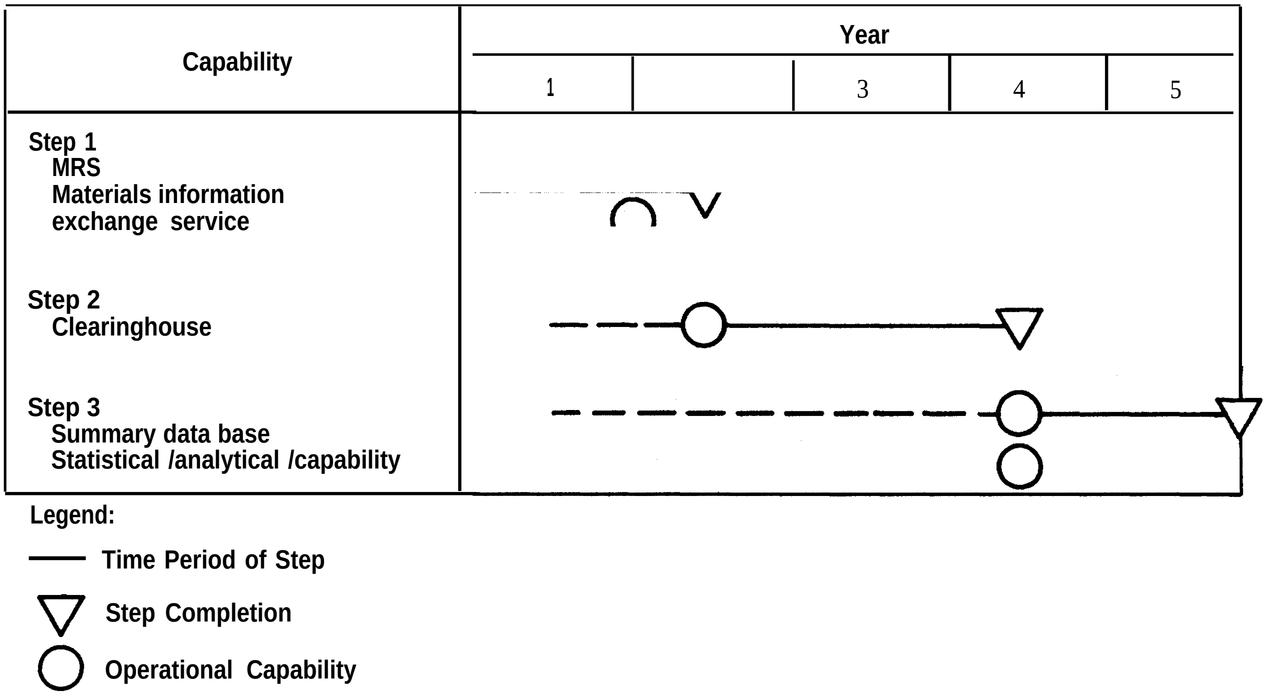
3. Approach B: Development, Automation, and Operation Costs

Cost estimates for this approach are dependent to a great extent on detailed decisions that must precede each step. It is impractical to postulate a 5-year plan posing costs for each possible alternative. The illustrative 5-year plan projected in table V–5 assumes that the evolution of approach B will begin with the materials referral service (MRS) and proceed to full statistical/analytical operations on materials information supplied by the existing agencies and placed in a summary data base.

For step 1, personnel costs are the major element. The numbers of people involved will vary during the step; however, implementation of this approach assumes an evolution of the MRS to provide continually increasing capabilities. For this reason, the costs of this step are shown for an 18-month plan.

The function of the MRS is to refer requesters to data sources. As such, the MRS staff would comprise primarily librarians and indexing specialists. However, the MRS would need broader knowledge of materials information to develop the basic data required for upgrading or evolving to steps 2 and 3, creating the need for information analysts and subject matter specialists. The initial task of the MRS during the first 6 months is envisioned to identification of the reference materials required and creation of the indexes to those materials. Having accomplished this, the MRS staff would then be supplemented with the information specialists and additional subject matter specialists to be operational during the last 6 months. Additional clerical/administrative support would also be required at this time in order to start compilation activities in preparation for step 2, Computer costs for the MRS

Table V-5.—Approach B Development Schedule



during this early phase of the approach are seen to be negligible because it is assumed that automated support, including online computer support, would be provided by the existing agencies.

For step 2, at the end of 18 months, an initial clearinghouse capability would be operational; support provided in addition to expansion of the MRS function would include indexing and abstracting plus the completion of a materials thesaurus, master directory, and data element dictionary. Feedback and utilization statistics would be accumulated to provide a basis for systems improvements. In addition to skills already established in step 1, commodity specialists, information systems analysts. systems and applications programmers and computer operations personnel would be added to the staff. An in-house computer might be requi red to provide the requisite support.

In step 3, the requirements for summary data bases would be established and implemented in such a manner as to provide an initial operational capability for selected materials within a 3.5 year time frame of the 5-year plan. It should be noted that the time period and resources to develop this capability would be significantly less than those required in approach 3. Considerable experience would have been obtained from the MRS and clearinghouse development. and information provided would, to a great extent, be prepared by the agencies. In addition, service would be limited in this approach to those questions which can be measured with the analytical capabilities available within the expanded MRS. Requests for data outside the purview of the MRS would be referred to the appropriate agency. New skills required to support this function would include subject matter specialists, systems engineers, data base/data communications experts, increased programming and computer operations staff and, in particular, experts in the fields of materials modeling, statistics, and analysis. Computer utilization would be expected to increase during this period to meet user requests as well as to provide system development support,

Table V-8 presents the average costs for approach B over 5 years, In addition to the costs

Table V-6.—Approach B Costs

Item	Cost per year ($ million)					Average Yearly Costs ($ million)
	1	2	3	4	5	
Development personnel (number) ...	(15)	(30)	(40)	(30)	—	
Development costs	$1	$2	$2	$2	—	$2
Operational personnel (number).....	(85)	(160)	(210)	(260)	(280)	
Operational costs.................	$4	$7	$9	$11	$15	$9
Automation costs	$1	$2	$5	$6	$6	$4
Total cost	$6	$11	$16	$19	$21	$15

Note: Costs are for the oversight organization and its new services. An additional $2 million may be needed annually to modify existing information systems to conform with this approach. This estimate is based on the assumption that some of the existing information systems would be utilized.

associated with the development and operation of the additional capabilities, there would be modification costs for the existing agencies to support the referral and clearinghouse services. It is estimated that this cost would average an additional $2 million annually for 5 years. As with approach A, the increased data collection costs would average $2o million annually over the same period.

4. Approach C: Development, Automation, and Operation Costs

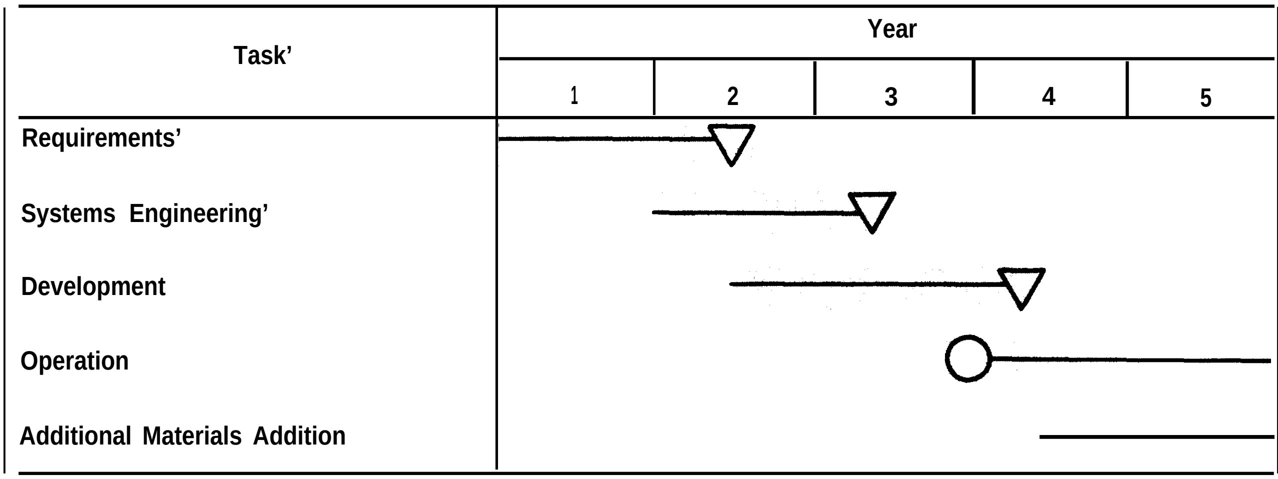
An accurate estimate of the investment required for this approach must be preceded by a detailed analysis of requirements and of existing information systems, to establish which could be utilized as part of the new information "system" developed.

The development of the required integrated capabilities by this approach would certainly impact existing information systems. However, the magnitude of the impact is difficult to estimate because it is a function of numerous variables, such as conversion costs, to interface with the new system, the degree of data aggregation/disaggregation, and the extent of disruption of existing information system operations and consequent need to provide backup. In the absence of a detailed analysis, a very rough estimate of $10 million was made; this is based on the assumption that the existing information systems are used to a large extent.

Approach C envisions the development of the integrated capabilities to be spearheaded by a few agencies, such as the Bureau of Mines and Department of Commerce, which would develop a prototype system to provide full functional support for a limited number of commodities. Such an approach is cost effective because the prototype development would be an early product of the overall system development activity and, at the same time, would provide the benefit of an early, limited operational capability with negligible increased cost. This would allow identification of required refinements, which could then be added since only a few materials would make up the data base. Additional commodities could be added on an incremental basis after the refinements were made. Further, since this approach provides the framework upon which additional commodities can be added, it is conceivable that the remaining commodities could be added without disruptions. In that case, the cost impact would be reduced and the workload might be accommodated by the permanent staff with only minor nonrecurring costs.

The overall development schedule for this approach is shown in table V–7. Work tasks

Table V-7.—Approach C Development Schedule



● Overlap of these tasks provides for refinement or requirement

Legend:

▽ **Completion of Task**

O **Initial Operational Capability**

during the first 2 years of systems development would be focused on requirements definition and overall systems engineering. Computer time would be negligible in the first year and would not start building up until the latter half of the second year when development would begin. In the third year development activity would peak and increased computer utilization would require nearly full-time support. Initial prototype system development test would be performed by connecting the new information system to one or more existing information systems late in the third year. This would further increase the workload so that by early in the fourth year full-time computer support would be required. Although new development activities are seen to decline in the fourth year, support to cover new commodities and more requests for information would continue to keep computer utilization at a peak level through the last year of the plan period. The average estimates of costs for this approach over 5 years are presented in table V–8.

In summary, approach C would average annual costs on the order of $2 to $20 million over the 5-year period to complete data collection and validation and would involve annual costs on the order of $17 milIion, averaged over 5 years, to establish the new information system capabilities needed, It would use the existing information systems to a large extent, and the increased costs, averaged over 5 years, in connecting these systems would be on the order of $2 million annually. If it developed that existing systems could not be extensively used, the increased costs could be substantially more.

E. SUMMARY

This section summarizes the strengths and weaknesses of the three illustrative approaches from an information system standpoint; in chapter VII their social, political, legal, and other impacts are analyzed. It is assumed in this comparison that the integrated capabilities are designed and implemented to support policy makers concerned with shortages in developing long-range contingency plans and short-range responses to crisis situations. It is also assumed that the particular critical material(s) will already have been

Table V-8_Approach C Costs

Item	Costs per year ($ million)					Average Yearly Cos s ($million)
	1	2	3	4	5	
Development personnel (number) . . .	(50)	(90)	(1 10)	(75)	(50)	
Development costs	$2	$4	$5	$3	$2	$3
Operational personnel (number)	(50)	(1 50)	(250)	(340)	(450)	
Operational costs	$2	$6	$10	$14	$18	$10
Automation costs	—	$1	$4	$6	$6	$4
Total cost	$4	$11	$19	$23	$26	$17

Note: Costs are for the new organization and its information system. An additional $2 million maybe needed annually to modify existing information systems to conform with this approach. This estimate is based on the assumption that the existing information systems would be utilized.

selected. The following characteristics were used as yardsticks to compare the approaches:

- Time to Achieve Operational Readiness.—The scale is marked in weeks, months, and years.
- Technical Application Constraints.—This refers to the amount of work required to convert technical knowledge into routine operating practice. The scale is marked as none, small, and large.
- Constraints on Access to Needed and Expertise.—This refers to the problems which will arise in carrying out the approach in having access to needed expertise to solve the problems. This scale is marked in none, few, and many.
- Administrative Authority .—This refers to the degree with which the assigned agency or group can ensure that the information plan is carried out. The scale is marked in weak, strong, and total.
- Budget Control.—This refers to the ability of an assigned agency or group head to control the money needed to implement the approach. This scale is also marked in weak, strong, and total.
- Continuity—This refers to the combined effect of management attention and the availability of staff to carry out the work on a sustained basis. This scale is marked ad hoc, periodic, and steady,
- Incremental Cost.—This refers to the relative size of additional expenditures required to set up and operate the approach (over and above the estimated initial data collection cost of $2o million which is common to all three approaches). This scale is marked low, medium, and high.

1. Approach A

The strengths of approach A are:

- The incremental cost could be relatively low, As developed in the cost analysis, about $10 million could be spent over 5 years. Approach A would use existing information systems and operating personnel, as well as planned improvements presently underway.
- Initial operational readiness could be achieved in a short time, possibly in a matter of weeks, assuming the needed data are already available. When Congress or another authority decided that a specific material or group of materials needed attention, the coordinating group

could form a task force of experts from within the existing agencies. If the material of interest is one that was already identified as such, it may have already been studied extensively by the materials management systems now in place, In other words, the job could be handled by a knowledgeable task force as it has been in the past. However, if the material in question had not been foreseen as potentially important, it might take months and even years to obtain the needed data.

- There could be essentially no technical application constraints. Routine operating practices of the existing information systems would remain the same.
- Problems in access to needed expertise could be none or few. Existing channels of communication between agencies and between public and private sector could be used.

The weaknesses of approach A are:

- Administrative authority could be weak, The coordinating group established to collect the data would have to do so via committees, task forces, or similar administrative devices. Such devices maintain their authority base for a short term in response to crisis situations, but over the long term, authority dissipates rapidly as the crisis passes. In general, this lack of authority could likely impose serious limits on the extent to which many problems involving interagency aspects of the information system could be solved (data transfer, standardization, etc.).
- Budget control could be weak. The coordinating agency could find it difficult to ensure that performing agencies allocate the money needed to be fully responsive to the coordinating group's requests.
- The ad hoc procedures and ad hoc staff could seriously impact continuity, When the need arose to restudy a specific material's shortage potential at various time intervals, it could likely be necessary to rebuild a coordinating mechanism each time.

The overall appraisal of approach A indicates that it would be well suited to those circumstances where the materials information needed to provide early warning of a shortage, including the probable effects of alternative policy responses, already exists in the Government. Unfortunately, this assessment has found few circumstances where these conditions exist.

2. Approach B

The strengths of approach B are:

- Continuity could be steady. It could be possible to set up a management measurement system and to monitor results against objectives, as well as to maintain visibility of critical materials in the intervals between formal reviews.
- The technical application constraints could be small. The work needed could consist in large part of setting up interfaces between existing information systems and the new information services being established such as referral and clearinghouse. The existing information systems could continue to operate and collect the needed data,
- The time to achieve operational readiness could be measured in months because of the step-by-step approach, Significant delays could arise primarily from obtaining initial authorization to establish the oversight organization. Once this was done, the approach could likely show tangible results in a matter of months.
- Administrative authority could be strong, at least, in the short term. Precautions could be needed, however, to ensure that the oversight organization retained its initial authority over the long term. The

step-by-step approach could permit flexibility in controlling and attaining development priorities as new needs were identified.

- The incremental cost could range from low to high, depending upon how far the step-by-step approach was carried. Initial costs for the first step could be low, approximately those of approach A. If all the steps were added incrementally, the total incremental cost of this approach could be high, approximately equal to approach C. A key cost consideration in this approach is that Congress could have the opportunity to review the results of each step before it appropriated extensions.

The weaknesses of approach B are:

- Budget control could be weak. The oversight organization could have the opportunity (and the responsibility) to advise on the funding levels needed by the various participating agencies to perform their assigned tasks. Such intervention could be made annually as budgets were prepared. However, the control over actual expenditures could remain with the various agencies.
- Access to needed expertise could involve many problems. Some could arise from uncertainties in the private sector over the system's ability to protect proprietary information. Others might result from evasive actions by individual Federal agencies to safeguard the autonomy of their missions, and from resistance to rules suggested by the oversight organization to minimize interface problems.

Approach B is especially attractive in its flexibility and adaptability to unforeseen circumstances. The step-by-step nature of the approach could ensure feedback before each major commitment was made. It may also be the best approach because of its high utilization of the significant investment in existing information systems.

3. Approach C

The strengths of approach C are:

- Administrative authority could be very strong. The agency responsible for the new system could be able to exercise a span of management measurement and control across the entire range of the objectives authorized by Congress.
- Budget control could be total. Funds could flow directly from Congress to the responsible agency through the established authorization and appropriation process. Transfer of funds to the performing agencies could be at the discretion of the responsible agency.
- Continuity could be steady. The management and staff could be in place for the long term to design, install, operate, and modify the new information system to meet new problems.

The weaknesses of approach 3:

- The time to operational readiness could be years. This approach is a long-term solution. The primary time delays could arise from the processes by which legislation is formulated and passed and the building of an effective organization. *
- The incremental cost could be relatively large. Further, this cost could vary significantly depending upon the extent of utilization of existing systems. Congress would likely have to commit to the whole incremental cost for this approach before initial work could be undertaken with confidence.

The access to needed expertise could encounter many problems. In addition to

*There may be no direct analogies in the physical sciences, but the timetable for the Lister Hill Center for Biomedical Communications in HEW is indicative. It was more than 2.5 years from the time it was formally proposed until P.L. 90-456 authorized its establishment, and another 2.5 to 3 years before funding, staff, and facilities were in place to begin meeting its objectives, those problems noted in approach 2, additional problems may arise as the agency responsible for the new information system hired knowledgeable people from the existing information systems and thereby reduced their capacity to participate effectively. New staff would also have to be built up to establish new interfaces with industry, a time-consuming process,

- Technical application constraints could be large. While approach C offers the opportunity to design a system from the start using the latest techniques, there are two classes of problems that could require continuing trade-offs in the new information system design. The first class of problems could arise from the fact that no one has yet designed an information system of this scope, especially when the supplementary functions are considered, The second could arise from the efforts that would be made to get maximum use of the existing information systems; it could be necessary to modify their internal operations to achieve system compatibility. This may impact their ability to perform their assigned functions.

Although, in principle, the advantages of approach C outweigh the limitations, it is based on the assumption that decision makers can fully define their system requirements and that false starts can be minimized. Recognizing the uncertainties in the ability to define the materials problem, and keeping in mind the pace of change in relevant information technologies, this approach may represent an unacceptably high risk.

Chapter VI

ALTERNATIVE INSTITUTIONAL ARRANGEMENTS FOR IMPLEMENTING THE INTEGRATED CAPABILITIES

Chapter VI

ALTERNATIVE INSTITUTIONAL ARRANGEMENTS FOR IMPLEMENTING THE INTEGRATED CAPABILITIES

Institutional change is necessary if Congress and the President decide to provide the integrated capabilities. Such capabilities could be located and operated in many institutional settings, including locations within the private and public sectors and within the legislative and executive branches to support public policymaking.

Seven alternative institutional arrangements are identified to illustrate the range of feasible possibilities. Among these, the Federal executive branch seems the most appropriate location, although supporting or related materials information activities may be located in the private sector, State/local government, the Federal legislative branch, and/or quasi-governmental organizations.

A. INTRODUCTION

The need for establishing the integrated capabilities to support public policymaking on materials-related problems raises fundamental questions about the institutional arrangements of such a system.

- Where would it be located?
- How would it be structured?
- What powers would it have?
- How would it operate?

The selection of appropriate institutional arrangements is critical to any option which Congress and/or the President may select for implemental ion.

This chapter will discuss institutional arrangements suitable for improving the existing materials information systems according to the three systems approaches described in chapter V. Each institutional arrangement will be analyzed in terms of location, function, and institutional structure. Among the institutional variables considered are: (1) the organizational framework of laws, rules, regulations, charters, etc.; (z) the basic powers and responsibilities of the unit and its parent agency, if any; (3) its autonomy from political or program influences; (4) control over the directorship, budgetary, administrative, and legal policies of the system; (5) executive and legislative oversight; and (6) access to the system by potential users. Other variables are the particular reputation, experience, and capability of possible institutional units or parent agencies: relationships with other governmental and private sector institutions; and possible disruptions or conflicts with ongoing programs.

Governmental institutions include executive branch departments and agencies including the Executive Office of the President, independent agencies, commissions, advisory bodies. Government corporations, legislative branch agencies, and other institutions which perform governmental functions, are funded by Federal revenues, or are under other direct Federal controls. Because the integrated capabilities are national in scope, the governmental institutions considered are Federal; however, State and local governments also may participate in their operations.

Private sector institutions include corporations and other business entities, whether for profit or nonprofit. trade associations and other special interest groups including public interest, environmental and other political or social associations, educational and research institutions, and other nongovernmental entities. Institutions which perform the integrated capabilities under Government contract are not considered to constitute private sector institutions because the primary responsibility for the system remains in a Government agency. However. a private sector institution which performs the integrated capabilities under its own control and management and supplies materials information to the Government as one of its customers is considered to be a private sector institution, even if some Government subsidies are received to support its activities

B. INSTITUTIONAL ARRANGEMENTS

1. Institutional Arrangements for Incremental Improvement of Existing Systems

As documented in the survey and interviews, many Federal agencies and private sector institutions are currently engaged in the collect ion and analysis of materials information, These activities can continue to develop through the incremental improvement of existing systems. Three possible institutional arrangements for incremental improvement are considered here. The first arrangement reflects increased Federal commitment to the many separate information systems under the individual control of existing Government agencies and private institutions, The second arrangement includes the establishment of a materials referral service in some Federal Government location to direct materials informat ion inquiries to appropriate information sources. The third institutional arrangement provides for a coordinating board or committee to develop guidelines for the operation and incremental improvement of existing materials information systems. Both the referral service and coordinating entity are compatible with systems approach A.

a. Increased Federal Commitment to Government and Private Sector Materials Information Systems. Under this arrangement, all existing institutions would continue to administer their separate data collection and analysis programs. Increased Federal commitment to the development of materials information, through some of the kinds of legislative/executive options discussed earlier. could help encourage Government agencies and private sector institutions to improve existing information systems and to establish new data bases and analytic methods where needed.

With support from the Congress and the President, Government agencies could seek expanded powers, including authority to gain access to critical materials information, and improve and expand their data bases and statistical and analytical programs, Where appropriate, the Congress and the President could allocate adequate funding and other resources for automation of data bases and standardization of reports and measurements. Each agency would continue to set its own reporting and disclosure requirements. standards of confidentiality, and administrative policies, The costs of each system would be borne by the parent agency, with separate budgetary requests submitted to OMB and the appropriate congressional committees.

Private sector institutions which collect and analyze materials information—primarily corporations, trade associations, educational institutions and trade publications-might be encouraged in their activities by this increased (government interest in materials related information. (governmental interest could be expressed through voluntary exchanges of in format ion with the private sector. subscript ion to materials publications and services. and Government contracts, as well as through direct subsidies and grants. Private sector institutions do not possess the authority to command access to materials information which Government agencies may exercise and so must rely upon voluntary arrangements. contractual relationships, published data, and their own research. Private sector institutions need not respond to requests for information by the President. [government agencies. or Congress except to the extent required by law, and they have no responsibility to reply to inquiries by the public.

This arrangement will require no new or substantially modified Government entity. will entail minimum disruption of existing systems. and will not threaten existing agency or private sector control. However. without the organization and integration possible through an improved institutional arrangement, increased Federal commitment may result in further duplication of programs, incompatible information produced by separate data bases, overlapping and conflicting agency jurisdictions. and will probably inhibit comprehensive analysis of materials life cycles. Thus it seems evident that evolution of existing systems through increased Federal commitment without improved institution;]1 organization and integration will fall short of meeting the information needs discussed earlier.

b. Materials Information Referral Office. In this institutional arrangement, some organization and integration is added to the decentralized systems through a materials referral office established to direct information seekers to the appropriate sources. All existing materials data systems and other information gathering and analysis activities would continue under the control of existing institutions.

Within the executive branch, the most likely locations for the referral office are the Department of Commerce or the Department of the Interior, because they are charged with broad jurisdiction over natural resources and industrial materials. In the legislative branch, the referral service might be located within the Library of Congress. perhaps as part of the National Referral Center. The referral office would be charged with the responsibility for monitoring available materials information sources in the Government. the private sector. and through publications, as well as directing inquiries to the appropriate location.

In addition to serving as a clearinghouse for materials information requests from the public. industry, and Government, the materials referral office would collect items of special relevance to the materials cycle and publish periodic guides to such items and to material information sources. All Federal agencies which collect information relevant to materials supply and demand could be directed to provide the referral office with a descriptive index of the data collected and any materials publications, the office or person to who m information requests should be addressed, and fees, if any. for such service, The referral office could also obtain, on a voluntary basis. similar information from State and local governments and major private sector materials information sources. and in return would facilitate the flow of federally collected information to these sources.

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The possible advantages and disadvantages of a materials referral office for incremental improvement of existing systems are summarized in table VI-1. The referral office has the clear advantage of facilitating access to existing materials information sources, but does not go very far toward solving any of the more substantial problems of materials information, although it may lay the groundwork for future change.

c. Materials Information Coordinating Board. In this second institutional arrangement, a coordinating board or committee would be established to guide the operations and incremental improvement of separate information systems. This board or committee would monitor the performance of individual systems and suggest guidelines for system operation and improvements. Members of the board or committee could be appointed by the President and might include representatives of all materials information agencies, the Justice Department, OMB, materials regulatory agencies, Congress, the Comptroller General, and other relevant legislative agencies. In addition, the board or committee could provide for the participation of representatives of the materials industry, trade associations, information management specialists, and members of the public through advisory committees.

A Government board or committee could be given appropriate authority to acquire from Government and private sources the information concerning materials and information systems management needed to propose uniform standards for improved operation of the existing materials information systems. These guidelines should cover such matters as the treatment of confidential information, standardization of measurements and reporting, public access policies, indexing of available materials information, and improvement of systems operations. The board's or committee's proposals would be advisory in nature and implementation of proposed standards would be left to each institution. The board or

Table VI-1.—Possible Advantages and Disadvantages of a Materials Information Referral Office

Advantages	Disadvantages
Will not greatly disrupt the materials information systems of existing agencies.	May to some extent duplicate activities of agency public information offices.
Will facilitate the development of a group to serve as a focus for later and more substantial change.	Will probably require a new governmental unit.
Will provide a centralized location for referral to appropriate information sources, and thus may stimulate some improvement in existing information systems.	Will not solve most of the existing problems resulting from differing agency policies, nonuniform standards, multiple reporting requirements of separate information systems.

Possible Advantages and Disadvantages of a Government Coordinating hoard

Advantages	Disadvantages
May promote more uniform and compatible operation of individual systems.	May not insure effective coordination of separate information systems if many agencies reject proposed guidelines
May promote coordination of agency policies end activies on materials information	Will require many potential users to seek information from multiple sources.
Will not greatly disturb ongoing relationships between agencies and private sector data sources.	Will not solve those problems which stem from the basic institutional alinements and perspectives of individual agencies.

committee would not control any materials information bases—all decisions regarding data and information sources would remain with in the jurisdiction of existing institutions.

The board or committee would have a small supporting staff and budget which could probably be associated with the Executive Office of the President or a line agency such as the Department of Commerce or the Department of the Interior. As part of its mandate, the board or committee would supply Congress and the President with periodic reports on the operations and policies of Government materials information systems. The materials referral service previously described could be included within the mandate of the board or commit tee.

Possible advantages and disadvantages of a coordinating board or committee located in the Federal Government are summarized in table VI-1. The board or committee may promote more uniform operation and better cooperation among existing institutions, without greatly disrupting the decentralized system. But the lack of binding authority and dependence on voluntary agency cooperation might well render the board ineffective.

2. Institutional Arrangements for Major Improvements in Existing Systems: An Executive Branch Location

Most proposals for establishing the integrated capabilities to support public policymaking have placed the improvements with in an executive branch institution. For purposes of this study, executive branch institutions include executive departments and agencies (heads of which serve at the pleasure of the President), the Executive Office of the President, independent agencies and commissions (directors of which have fixed terms of appointment). and quasi-governmental institutions. This section assesses possible advantages and disadvantage ;s of each of these ex - excut ive branch inst itut ons as the arrangement most compatible with systems approaches B and C.

a. Location in an Existing Executive Department or Agency. Several pieces of legislation before the 94th Congress called for establishing a comprehensive materials in format ion system in an existing executive department or agency which exercises jurisdiction over one or more sectors of the materials industry. Examples of such locations include the Departments of Commerce, Interior, and Agriculture, the General Services Administration, and the Federal Energy Administration. This study does not attempt to assess the comparative advantages and disadvantages of locations in these agencies, but rather seeks to identify the general advantages and disadvantages of executive departments and agencies as compared with other alternative institutional arrangements.

The basic powers and responsibilities within an executive department or agency would derive from the existing mandate of the agency and from specific implementing legislation and directives. The primary functions would be performed by this unit in addition to management of the system and coordination of supporting activities of other agencies. Since this arrangement. like the others. would use existing data bases maintained by individual agencies, necessary authority must be granted to allow transfer of relevant materials in format ion from the primary source agency. Appropriate standards for protection of information subject to claims of confidentiality must be established for exchanges between Government agencies and private sector respondents.

To ensure that timely, comprehensive. and reliable data will be provided. the institutional unit might be empowered to require submission of materials data from private sources where no Government agency collects the necessary information. as well as authority to compel access to **private sector** materia1s data. books. records, and sites for validation purposes. As an additional incentive to the completeness and reliability of the integrated capabilities. the General Accounting Office might be empowered with full authority to review all raw data submissions by Government and private sources and to inspect respondents' books, records. and facilities for validation purposes.

The institutional unit would monitor all factors affecting the materials life cycle. in addition to materials supplies and consumption, and would provide periodic and special reports to Congress and the President on the national materials situation. These reports would be in addition to supplying continuous access to current and complete materials data to Government and the public. Enabling legislation could promote responsiveness to Congress by specifying compliance with congressional requests for materials information and analyses, Public access to improved materials information could be enhanced by a firm legislative statement directing maximum operational openness in and limiting grants of confidentiality,

Principal funding for development and management would be contained in the budget of the parent agency. Other agencies would bear a proportionate share of the costs of maintaining and using the integrated capabilities. Costs of primary information gathering and processing activities would be borne by the primary source agency as a cost of its own data base. Costs of special requests for information from agency data bases would be assessed to the responsible institutional unit, Only search and reproduction costs would be recoverable from public and industry users, as allowable under the Freedom of Information Act. Consideration should be given to the establishment of reasonable fees for tie-in subscription by private systems.

Possible advantages and disadvantages of locating the integrated capabilities in an existing department or agency are summarized in table VI-2, On one hand, the reputation, experience, management structure, and authority of a supportive parent agency could help insure effective interagency cooperation and provision of required resources. An existing agency location will likely minimize the disrupt ion of ongoing Federal programs and private sector relationships (as compared to a new agency), On the other hand, the parent agency, may be inf1uenced or even ''captured by political or policy preferences, impairing credibility or leaving the integrated capabilities in an incomplete and weakened status if other Federal agencies and/or the parent agency refuse to or cannot cooperate,

b. Location in a New Executive Department or Agency. There are two possible institutional arrangements in a new executive department or agency, Under the first of these possibilities, the integrated capabilities would become part of a new executive department such as the proposed Department of Energy and Natural Resources. Under the second possible institutional arrangement, a new statistical agency would be created, While each of these arrangements reflects many of the advantages and disadvantages which attach to existing executive departments and agencies, there are sufficient differences to warrant separate considerate ion,

Department of Energy and Natural Resources.-In recent years, there have been several proposals for the establishment t of a new "super department" with jurisdiction over matters pertaining to natural resources and energy. Programs and offices dealing with these subjects which are, at present, scattered among severa1 departments and agencies would be reorganized u rider the aegis of a single department. Existing energy and natural resources statistical programs in the Departments of Agriculture, Commerce, and Interior would be among those transferred to the new super department which would then become. perhaps, the most appropriate executive department location.

The institutional unit would be charged with the responsibility y for establishing and maintaining a centralized materials information system with the capability of monitoring all relevant factors affecting materials supply and demand for the benefit of the Executive, Congress, business, and the public. In addition to gathering. processing, and distributing materials information utilized in the central system, the unit would have the responsibility for coordinating Government materials infor-mat ion activities and assuring the compatibility of contributing data bases and systems with the central system. Most of the data would rely upon materials information now collected by individual agencies under new and existing Federa1 programs. Therefore, appropriate authority would be granted to assure interagency cooperation while maintaining necessary protection for confidential information. In order to carry out its functions. the institutional unit could he empowered to require submission of relevant materials information from private sector and Government sources where such information is not contained in existing Federal data bases or is not readily accessible therein.

Responsibility for verifying, periodically, the accuracy of submissions could be granted to the centralized system, It could. for purposes of such validation, be authorized to seek access, by subpena if necessary, to materials information and supporting books, records, documents, and other evidence, including trade secrets and other privileged and confidential information in possession of various

Table VI-2.-Possibie Advantages and Disadvantages of a Location in an Existing Executive Department or Agency

Advantages	Disadvantages
May enhance credibility if adequately insulated from internal agency infiuence by creating a separate bureaucratic unit (e.g., Bureau of Labor Statistics, Bureau of Census, and DoA Statistical Reporting Service).	May be exposed to the possibility of influence by political and policy preferences.
Will locate in an operating structure can provide the required resources and sustain the necessary expansion of activities.	May be "captured" by its parent agency through direct or indirect pressures to report or interpret materials statistics so as to further the parent agency's image or programs.
May be strengthened through the reputation, experience, management structure, and existing operating authority of the parent agency.	May impair the credibility.
May help assure interagency cooperation, if the parent agency is fully committed to and supportive.	May exacerbate existing competition between agencies and creation of new rivalries, in part because of dependence upon information gathering authorities and data bases of numerous Federal agencies.
Will provide materials information seekers with a single location for information requests.	Will be subjected to general control of the parent agency over management, legal policies, and resource allocation, and to intra-agency competition for funds and personnel.
May help promote uniform policies of public access, disclosure, and confidentiality, and standardization of reporting forms and units of measurement.	May create some minor disruption of ongoing Federal materials programs in order to accommodate information needs and improve compatlbility of existing systems.
Will not substantiality interfere with existing relationships between Federal agencies and information sources in the materials industry, since existing agencies will continue to be the primary agents for data collection.	Myy be incomplete and impaired, if the other Federal agencies and/or parent agency rafuse to or cannot cooperate in meeting information needs.
May help eliminate some duplication in existing facilities and programs.	

Government agencies and private sector institutions. As part of its functions, the institutional unit would provide materials information clearinghouse and referral services, issue periodic reports, and upon appropriate request, supply special reports to the President, executive branch agencies, and the Congress.

Possible advantages and disadvantages of a location within a new natural resources super department are summarized in table VI-3. This location will likely facilitate the ability to provide for uniform systemwide policies on materials information, to improve compatibility through modifications in existing systems, and to eliminate duplicate programs and activities, On the other hand, location in a super department will unduly delay implementation (since a super department is years away), will likely disrupt many governmental programs, may increase the possibility of department influence on statistics and analyses, may therefore diminish the unit's credibility and may heighten both inter- and intra-departmental competition for resources and prestige.

New Statistical Agency .—Several of the disadvantages associated with a location in a natural resources super department might be overcome by the creation of a new statistical agency to develop and operate the integrated capabilities. This agency would be under the direction of an Administrator appointed by the President and confirmed by the Senate; its sole responsibility would be the development and maintenance of a centralized materials information system serving the needs of the executive branch, Congress, business, and the public. While the President would exercise some control over the agency through the

Table VI-3.—Possible Advantages and Disadvantages of a Location Within a New Natural Resources Department

Advantages	Disadvantages
Will provide for uniform systemwide policies of public access, disclosure, and confidentiality, and for standardized reporting forms and units of measurement.	Will undoubtedly disrupt many Government programs as a result of the massive reorganization required.
Will permit simplified access through a central location for all information requests.	May be exposed to a greater possibility of departmental influence on statistics or analyses.
Will reduce the number of interagency contacts which might otherwise hamper timely exchange of information because of agency rivalries.	May diminish credibility due to identification with a super department with vast policymaking and program-implementing responsibilities.
May make possible the elimination of duplicate programs and facilities and consolidation of other statistical programs thus reducing the costs of the whole system.	May heighten any rivalries with existing Government agencies due to their loss of programs to the super department, program-implementing responsibilities.
Will facilitate modifications in existing systems to assure compatibility with NIMIS through intra-departmental action alone.	May be subject to greater intra-departmental competition for resources and prestige.
May build more effectively on the accumulated reputations, experience, and capabilities of existing systems.	May expose confidential information to increased risk of inadvertent disclosure.
	Will unduly delay implementation since a super department is probably years away.
	May reduce flexibility of the system to respond to diverse specialized information needs.

power of appointment and removal, the Administrator would have a responsbility to exercise independent judgment.

This materials information agency would publish periodic reports on materials availability and consumption and other key variables. In addition, the agency would respond to special requests for materials information from the President and Congress. The agency would provide basic materials life-cycle data, statistical analyses, trends and forecasting capabilities, and other services of a statistical or informational character. It might also provide policy options or policy analyses.

The agency would have primary responsibility for recommending necessary changes in existing materials information systems to assure compatibility with the integrated capabilities. These recommendations could be implemented through independent action by primary source agencies, OMB directives, or by legislation. The agency would utilize existing data bases where possible and would continue to rely on existing agencies and departments to act as collection agents for primary materials data for the central system. The agency could be given appropriate authority to require necessary and relevant information from Government and private sources and might, for validation purposes, have access to all raw data under control of contributing primary source agencies and to private sources' books, records, and facilities. Appropriate protection would be given to confidential information, and confidential or privileged information in the possession of other Government sources would be released only as specifically required.

Possible advantages and disadvantages of a new materials information agency are summarized in table VI-4. This location will enhance the agency's credibility by making it independent from policymaking functions, will remove it from potential pressure by a parent agency, and will place it in one of the strongest institutional positions within the executive branch to represent itself before the President and Congress and to secure necessary support and cooperation. While disruption will be less than a super department, a new agency will still require additional bureaucratic overhead and administrative structure, may experience a start-up delay, and in the final analysis, may not be given the authorities and resources necessary to carry out its mission.

c. **Location in the Executive Office of the President.** Another possible institutional location is within the Executive Office of the President (EOP). There are several justifications for such a location. A comprehensive materials information system cuts across departmental and agency boundaries in its scope and jurisdiction and depends upon agency data and analytic support. Location in a supra-agency position within the executive branch would permit coordination and management of activities without exacerbating agency rivalry, overlapping jurisdictions, and disrupting of ongoing agency programs. In addition, the management authority over data reporting requirements, confidentiality, standardization of units of measurement and geographical units, and disclosure policies would be exercised through the President's authority over the agencies.

The integrated capabilities are national and international in scope and are intended in part to support important national policy decisions which are made or approved at the Executive Office level. Through the authority and prestige of the President, information and expertise from Government and corporate sources would be readily available to an EOP unit. There are several possible existing Executive Office locations, such as the Office of Management and Budget, Domestic Council, or Council of Economic Advisors. A new executive office or council might be established similar to the Coordinating Board discussed earIier, or a smaller unit such as the three member Council on Materials Management proposed during the 94th Congress in S.1415.

Given the size of the Executive Office of the President and its limited personnel and resources, a unit located there would at most perform management and coordination functions, publish summary data in report form, and provide high-level analytical and policy support to the Executive. Therefore, the unit would rely on existing agency and other data sources to perform primary data collection and analysis. Since the validity of data would depend upon the quality of agency sources, the EOP unit might be given the authority to request any relevant information not already collected by Government agencies-either by direct request to the source or by delegation to the appropriate agency. Agencies would provide. supplemental materials information analysis upon request of the EOP unit.

Possible advantages and disadvantages of a location within the Executive Office of the President are summarized in table VI-5, An EOP location may increase visibility and prestige, strengthen management of agency activities and access to materials information and expertise. and minimize direct conflicts over operations and policies. However, this location may be viewed as an unwarranted expansion of Presidential power, may subject the unit to the influence of political preferences and claims of executive privilege, may therefore impair its usefulness to Congress and the public, and, overall, may place severe constraints on the scope of operational activities.

d. Location in an Independent Agency or Commission. From the standpoint of this study, the primary differences between executive agencies and independent agencies is in the directorship of the institution. The director(s) of an independent agency are appointed

Table VI-4.—Possible Advantages and Disadvantages of Location Within a New Statistical Agency

Advantages	Disadvantages
Will enhance credibility by making the agency independent of any policymaking functions.	Will require the creation of a new governmental institution.
Will remove from potential pressure by a parent agency.	Will require its own administrative structure, personnel, and support facilities.
Will minimize disruption (compared to a super department or super information agency) since existing systems would be supplemented, not replaced, and massive reorganization would not be required.	May experience a start-up delay, like other new institutions.
May facilitate uniform systemwide policies of access, disclosure, and confidentiality; simplified user access; standardized reporting forms and units of measurement; and elimination of many duplicate facilities and programs.	May deprive of experience available if located in an existing institution.
Will eliminate intra-agency competition for resources and prestige.	May not be given the authorities necessary to carry out its mission.
Will be placed in one of the strongest possible institutional positions within the executive branch to represent itself before the President and Congress and to secure necessary support and cooperation.	

Table Vi–5.—Possible Advantages and Disadvantages of Location Within The Executive Office of the President

Advantages	Disadvantages
May minimize direct conflicts between executive agencies and departments over operations and policies.	May be viewed as an expansion of Presidential power.
May strengthen access to materials information and expertise through E.O.P. authority and prestige.	May be subjected to the direct influence, real or apparent, of political preferences.
May strengthen management and coordination of agency activities.	May be subjected to claims of executive privilege and thereby limit usefulness to Congress and the public.
Way increase viability and prestige.	May impair congressional and public access to the system.
	May be weakened or "orphaned" if the President is not fully supportive.
	May place severe constraints on the scope of activities and the level of available resources.

by the President with the approval of the Senate and serve for a fixed term of years like members of regulatory commissions; the head of an executive agency serves at the pleasure of the President. The principal advantage of the fixed-term appointment is the increased autonomy of management in setting internal policy for the system and in providing unbiased analyses. In addition, certain professional or other qualifications for the directors might be specified to further promote their independence.

As in other institutional arrangements, the in depend en t agency would coordinate materials information activities and provide a centralized depository for materials data. The agency would, through transfer of existing functions or interagency agreements, build upon existing data bases and relationships maintained by other Government agencies. The agency could be empowered to require information from governmental and private sources, and could have access to all necessary documents, books, and records for validation of data submissions. An independent agency could also be an appropriate institutional structure for a comprehensive system in which the agency was the sole collector of primary materials information from private sources for all Government agencies,

Because of its independence, the agency would be co-equal with other Government institutions, It would control its own fiscal, administrative, and legal policies within the broad guidelines set by the Executive. Appropriate oversight authority could be vested in GAO to promote the accuracy and reliability of system information, The agency would be required by legislation to respond to requests for information and analyses by Congress and the President. As part of the Federal Government, the agency would be subject to openness requirements of the Freedom of Information Act and procedural requirements of the Administrative Procedure Act. The agency could be made even more responsive to public demand for information through requirement of published reports at regular intervals, with well-defined limits on confidential information. User fees could be reasonably set to promote use by private citizens and business.

Possible advantages and disadvantages of a location in an independent agency or commission are summarized in table VI-6. This location will protect the agency from danger of

Table Vi-6.-Possible Advantages and Disadvantages of Location in an Independent Agency or Commission

Advantages	Disadvantages
Will prevent "capture" by a parent agency.	May be insulated from the information needs of Government agencies and the public.
Will permit more autonomy and control over its resources and policies.	May lose touch with critical specialized information needs.
Will be better insulated from political and other pressures or influence by the Executive or Congress.	Will cause some disruption in ongoing programs due to the reorganization required.
May permit uniform regulation of materials information reporting, disclosure, confidentlality, and public access.	Will require the creation of a new governmental institution and additional bureaucratic overhead.

being captured by a parent agency, will permit it to have more autonomy over its resources, and will better insulate it from political pressures. However, location in an independent agency may permit it to lose touch with critical information needs, may insulate it from information users, and will require the creation of a major new governmental institution with additional bureaucratic overhead.

e. Location in a Quasi-Governmental Institution. Several proposals have suggested that the integrated capabilities be located in a special quasi-governmental institution such as a Government-chartered corporation or a specialized association like the National Academy of Sciences. These suggestions are based on several assumptions. First, such an institutional location would be "independent of Government" and hence better suited to serve the materials information needs of both industry and Government, while at the same time drawing upon Government resources and information to support its activities. Second, because of its independence and "private sector" identification, a quasi-governmental institution could develop better working relationships with private industry, as industry would be more inclined to accept the objectivity of data generated and more likely to "trust" such an institution with its proprietary data than a Government agency. Third, a single location would be free of much governmental regulations, red tape, restrictions, and therefore would perform "better" than a similar governmental institution, Fourth, the institution could be "self-supporting" through user fees. Fifth, independence of the institution from both industry and Government would provide maximum protection of proprietary information.

f. Location in a Government-Chartered Corporation. One suggestion calls for creation of a quasi-governmental corporation with a structure similar to COMSAT—a federally chartered stock corporation which would develop and maintain a comprehensive materials information system serving the needs of Government and materials producers and materials consumers. Stock in the corporation would be sold to system users and the public, with the anticipation that the majority of shares would be held by system users. Incorporators of the corporation would be appointed by the President, approved by the Senate, and would elect its first Board of Directors. Thereafter, annual or other periodic reports on corporate activities and financial condition would be submitted to the President and Congress,

Initial funding for development of the system would be provided by one or more of these methods: direct subsidy by the Federal Government, sale of stock, loans to the corporation either guaranteed by the Federal

Government or held by the Federal Government, or loans or subsidies by private industry. Sale of stock in the corporation may be delayed until the system is operational, with costs and risks of development undertaken by the Federal Government. Since under this structure the corporation would ultimately be controlled by its shareholders and not the Federal Government, it would not possess any authority to compel disclosure of materials information from public or private sources. The system would rely upon published materials and the voluntary cooperation of governmental and private institutions. Access to the system would be gained by subscription, contract, or management discretion.

Possible advantages and disadvantages of a Government-chartered corporation are summarized in table VI-7. This location will place responsibility within a neutral independent institution, may enhance credibility of data and analyses. may create a self-supporting basis and increase the willingness of private companies to cooperate, and will not disrupt existing Federal programs. However, such a location may limit direct public use, may reduce responsiveness to Government and public needs, and may limit access to materials information in Government agencies.

g. Location in a Government Advisory Body. Another quasi-governmental institutional configuration would place some or all of the responsibility with the National Academy of Sciences or a similar body which traditionally has served in an advisory capacity to the Federal Government,

The Academy, although not a Government agency, has maintained a close relationship with the Federal Government since its establishment by Act of Congress in 1863. Its charter specifies that ". . . the Academy shall, whenever called upon by any department of the Government, investigate. examine, experiment, and report upon any subject of science or art, the actual expense of such investigations, examinations, experiments and reports to be paid from appropriations which may be made for that purpose, but the Academy shall receive no compensation, whatever, for any service to the Government of the United States. " Although no Federal funds are appropriated directly for Academy activities, the Federal Government provides the principal funding for its operations through the negotiation of individual contracts with Government agencies.

Under this institutional arrangement, one or more agencies of the Government would contract with the National Academy of Sciences or other advisory body to develop and maintain a national materials information service, perhaps along the lines of the TRIS (Transportation Research Information System) now operated by NAS. The advisory body would obtain materials data necessary for the performance of its functions from readily accessible Government data bases, publications, and by voluntary submissions of data by private sources. The expenses of the system would be undertaken by the Federal Government and any other subscribers. Management of the system would be supervised by an appropriate committee of NAS or other advisory body,

Because the advisory body is not part of the Government, it would not have any authority to compel disclosure of information by private or Government sources. However, through its contractual relationship with Government agencies it would gain access to all necessary and relevant data under Government control for its activities. Confidential information released to the advisory body for information system purposes would be protected by contractual provisions, specific terms accompanying release, and relevant Federal statutes restricting disclosure of such information. Confidential information voluntarily supplied by private sources under conditions of confidentiality would be protected from release, even to Government agencies, by the threat of civil liability for any harm resulting from such disclosure. Since the advisory body is not a governmental agency, it would not be subject to the public access requirements of the Freedom of Information Act. However, certain

Table VI-7.-Possible Advantages and Disadvantages of Location in a Quasi-Governmental Institution

Location in a Government-Chartered Corporation	
Avantages	**Disadvantages**
Will place responsibility within a neutral independent institution.	May limit direct public use due to costs involved in payment of user fees.
May enhance credibility of data and analyses to some sectors of government, private industry, and the public.	May limit access to materials information in Government agencies.
May be on a self-supporting basis through stock sales and user fees.	May impair the reliability and validity of data.
May increase the willingness of private companies to supply confidential and other materials information to a neutral entity.	May raise problems of accountability if the Government should participate in management of the corporation through stock ownership.
Will create no direct disruption of existing Federal Government programs.	May reduce the usefulness and responsiveness to Government and public needs.
Locatlon in a Government Advisory Body	
Advantages	**Disadvantages**
Will be insulated from direct Government control.	Will not provide authority needed for access to materials information from Government and private sources.
May encourage private industry to be more willing to supply sensitive, confidential information.	May impair the ability to operate effectively,
Will not require a major expansion of governmental activities.	Will require the negotiation and approval of complex contractual relationships with the Federal Government.
May enhance credibility.	May limit pubiic and Government access.
May more effectively insulate confidential information from unauthorized or harmful disclosure.	

activities of the institution might be subject to provisions of the Federal Advisory Committee Act, and indirect public access to system information could be obtained by FOIA request to the subscribing Federal agencies.

The system would exist in addition to materials-related data systems in individual Federal agencies, but it would not have any coordinating responsibility for agency information activities. It is anticipated, however, that any improved methods of materials data management or analysis would be available to the agencies for implementation into ongoing programs, Publication of annual or other periodic reports on materials resources, reserves, consumption, and other factors relating to materials supply and demand would expand the materials information generally available to business, educational and research institutions, and members of the public.

Possible advantages and disadvantages of a Government advisory board are summarized in table VI-7. This location will insulate the board from direct Government control, may encourage private industry to supply confidential information, will not require a major expansion of governmental activities, and may enhance overall credibility, However, location in an advisory body will not provide the authority needed to acquire necessary materials information, may impair the ability to operate effectively, and may limit public and Government access,

3. Location in the Legislative Branch

One of the most important goals of the integrated capabilities is to provide Congress with timely, accurate, and comprehensive information about the Nation's materials supplies and demands. Congress must, to a large extent, rely upon data and analyses submitted by executive branch agencies or upon materials submitted for legislative hearings by private sources, Some limited analytical capability is available in CRS, GAO, and OTA, and potentially in CBO, but these resources are stretched thin. Increasingly, legislation and proposals have appeared for the establishment of an independent congressional capability to prepare separate analyses for Congress, in addition to those supplied by the executive branch and lobbyists.

Such a need could be met by establishing materials information capabilities within the legislative branch, either within an existing legislative support unit or as a new legislative office. Because of the nature of Congress's information needs, such capabilities would deal largely with aggregate data and with trends, forecasts, and analysis of administration or congressional proposals. Its data base needs would not be as extensive as more comprehensive technical systems. Authority would be needed to obtain basic aggregate data from existing Government and private sources. Access for purposes of validation could be given to the materials unit or to GAO to check executive agency and private submissions.

As part of this congressional materials information capabilities, existing clearinghouse, referral, and analytical services provided by CRS and GAO would be improved, Congress would thus have its own independent source of materials information and analysis. which would not be directly accessible by members of the public since Congress is not subject to requirements of the Freedom of Information Act. However, information and analyses supplied to Congress by the unit would likely be published in legislative records and documents. This legislative unit would not serve needs of the Executive or other Federal agencies.

Possible advantages and disadvantages of a location in the legislative branch are summarized in table VI-8. The major advantage is that Congress would be freed from absolute reliance on analyses submitted by executive and private sources. Congress would have the benefit of independent judgment and analyses. The integrated capabilities would be limited in scope and complexity and would be integrated where possible into existing legislative support units.

The disadvantages of a congressional location are, first, that operations would rely primarily upon the voluntary cooperation of Government agencies and private institutions in supplying materials data to the unit. Large-scale refusal or reluctance by Government agencies to supply necessary information could limit the effectiveness of the system and reliability of data. Second, any congressional use of mandatory disclosure of information from Government or private sources would be cumbersome--either subpena power would have to be exercised by a congressional committee, or a legislative officer would have to be properly authorized to sue for the production of information. Third, establishment of a congressional unit would be constrained by the institutional and resource limitations inherent in a legislative branch location, While existing congressional offices-CRS, GAO, CBO. and OTA—might well be upgraded in the materials information area, in part through the support of evolving congressional information capabilities, the Congress does not appear to be a feasible location.

4. Location in the Private Sector

A final possible institutional arrangement is the establishment of the integrated capabilities in the private sector, Private sector institutions include business and educational institutions, and trade and special- interest associations. Their essential features are that they operate

Table Vi-8.-Possible Advantages and Disadvantages of a Location Within the Legislative Branch or Private Sector

Advantages	Disadvantages
Location in the Legislative Branch	
Will free Congress from absolute reliance on materials information and analyses supplied by executive and private sources.	Will not be directly accessible to public and executive branch.
Will provide Congress with independent analyses of materials problems and policies.	Will depend primarily upon voluntary cooperation of Government agencies and private sector for efficient operation.
Will improve existing congressional materials information systems.	Will be restrained by institutional and resource limitations.
Will not require an extensive data base.	
Location in the Private Sector	
May reduce demands on the Government for materials information.	Will not have authority to acquire materials data from Government and private sources.
May serve to supplement existing Government materials information systems.	May be incomplete and unreliable.
May reduce the need for new or expanded Government systems.	Will constitute a formidable barrier due to cost and legal limitations.
May promote private sector cooperation.	Will result in limited public and congressional access and use.
	May result in higher overall Government costs for materials information.
	May be "influenced" by materials corporations or industries, thus reducing overall credibility and utility of the system to others.
	May not go very far in meeting public sector needs for new or improved information, due to the proprietary nature of many private sector systems.

under self-management and are not under the direct control of Federal or local government—even though they may derive substantial revenue from Government sources.

Many private sector institutions are already engaged in gathering, processing, and reporting materials information. Thus, like Government, the private sector has decentralized materials information systems. These systems, like those in Government, cover man-y aspects of the materials cycle. Indeed, these private sector data bases are a major source of materials information for the Government and its systems.

Within a private sector location, the primary management and information functions would be placed in a single institution, with supporting functions provided by other entities, A private sector location would include an institution such as a corporation, trade association, or research or educational institution, This institution would gather, process, and report relevant materials information to users in Government, the private sector, and the public.

The primary authority for the private sector institution would be derived from its charter, by-laws. and the laws of the jurisdictions in which it operates. The entity may be either profitmaking or nonprofit, but for it to operate successfully it must be self-supporting. The institution would rely primarily upon materials data bases maintained by Government and private sector sources, Access to those sources would be dependent upon the discretion of the entity controlling the information and could be secured by appropriate contractual arrangements, Where applicable, access to Government-held information may be guaranteed by the Federal Freedom of Information Act and other Federal and local public disclosure requirements.

However, unlike Government-controlled systems, access to private sector systems is limited by private ownership, and access may be gained only by purchase or subscription. A system may be maintained by a trade association for the use of its members, with only limited disclosure to Government and the public through publications or other voluntary release. Other systems are maintained for internal management purposes and are kept highly confidential for competitive reasons. There is no requirement that information contained in these private systems be generally available to the public or Government.

Furthermore, information supplied to a private system by materials producers and their trade associations may, in some instances, be of doubtful reliability because of the possibility of intentional bias so as to distort the use of such information by Government, materials consumers, and other institutions, Within sectors of the materials industry, there is considerable distrust by companies of figures supplied by competitors to Government or trade associations.

In this competitive atmosphere, proprietary information, including data not normally considered privileged or confidential, is frequently guarded from disclosure to rival companies, potential suppliers, or customers. Even systems run by neutral trade associations or research and educational institutions suffer from the competitive atmosphere that exists within segments of the materials industry. The result is fragmented, incomplete, and often unreliable data bases producing information systems and analyses of limited depth, scope, and credibility which serve only a small number of the potential users. Finally, there is no private sector institution which could coordinate and interrelate the activities of the decentralized systems to provide timely, reliable, and complete information on the entire materials cycle to the Government, private industry, and the public.

Possible advantages and disadvantages of a location in the private sector are summarized in table VI-8, A private sector location for policy analysis may reduce demands on the Government for materials information, supplement existing Federal systems, and promote private sector cooperation. But at the same time this will likely obviate the authority needed to carry out the primary mission to support public policymaking, may produce an arrangement which is incomplete and unreliable, will result in limited public and congressional access and use and may permit influence by materials corporations or industries. Private sector materials information systems-especially with respect to scientific/technical information, clearinghouse/referral services, and forecasting/analytical capabilities in support of materials policymaking —might well be improved, through increased Federal Government support, But the private sector does not appear to be a feasible location for a major public policy-oriented arrangement,

C. SELECTED IMPLEMENTATION ALTERNATIVES

The analysis in the preceding chapter strongly suggests that, without direct and concerted action, the legislative/executive branch needs for improved materials information in support of public policymaking are unlikely to be met through the natural evolution of existing materials information systems. However, the analysis also indicates that increased Federal commitment through one or more of the possible legislative/executive options will not by itself insure that existing systems evolve to meet the priority information needs. Regardless of the level of commitment, additional organization and integration seems essential. Various levels of organization and integration may be introduced through the alternative institutional arrangements as well as through the systems approaches discussed in chapter V.

1. Rationale for Specific Alternatives

a. Potential Users and Information Needs Determine Objectives. Selecting specific alternatives depends in the first instance on the potential users and their information needs, as translated into objectives to be achieved. In this assessment, the focus is on materials information for public policymaking. Thus, the primary potential users include policy makers in the legislative and executive branches of the Federal Government (e.g., Members of Congress and congressional staff, the President and executive-level staff department and agency heads and their staffs), and the primary need is for inventory/economic information. However, for the reasons discussed in chapter 111. the alternatives should give some consideration to other users (e.g., private corporations, and trade associations, consumer and environmental groups, and research and educational organ izations), as well as State and local governments.

b. Alternative System Approaches. The implementation alternatives involve different systems approaches, with appropriate levels of authority, to achieve the integrated capabilities,

In terms of services, the approaches range from (a) a materials information referral service (to help users locate existing information sources); (b) a materials information exchange service (for effective interchange of information among existing systems); (c) a summary materials data base (summarized and aggregated data from existing and/or new systems); (d) a clearinghouse or query management service (to respond to user requests for materials information in various formats); (e) statistical analysis and forecasting; and finally to (f) a detailed materials data base (detailed as well as summarized data from existing and/or new systems),

With respect to functions, the approaches are based on a life-cycle concept for managing materials information. The life-cycle concept includes information on all stages of the cycle of materials supply and utilization, from acquisition of raw materials (e.g., exports, stockpiles, or reserves) through processing (e.g., beneficiation, refining, and smelting) and manufacture to eventual consumption, and end-use (e. g., disposal. re-use, or recycling). This concept can also include information on interrelationships between the materials life cycle and, for example, energy input, labor and transportation requirements, and environmental impact.

The life-cycle concept provides the basis for a wide range of statistical analysis and forecasting functions, such as estimating the potential scarcity of selected commodities or determining the environmental impact of substituting one material for another, and also provides a framework for the referral and exchange of materials information.

With respect to information technology. the capabilities and functions discussed above are dependent on improvements in both nonautomated and computerized data bases data processing, statistical analysis, and forecasting. Three basic systems approaches which can provide this information support are discussed in chapter V:(1) incremental in improvement with in the context of existing systems and institutions (to be accomplished by essentially the same people, in the same organizations, with the same tools); (2) sequential improve*ment* building on existing systems and institu - tions but including some new or substantially modified systems and institutional arrangements: and (3) "total systems" improvement whereby a new materials information system is designed and developed from scratch with significant consolidation of functions from existing systems and including a major new institutional arrangement.

c. Institutional Arrangements. All arrangements will relate to and. where appropriate, build on the institutional arrangements associated w i t h existing materials in formation systems, The integrated capabilities could be operated in many places, including locations within the private and public sectors. and with in the legislative and executive branches of the Federal Government, However, since the primary objective is to support public policymaking, the number of feasible institutional a arrangements can be substantially reduced. Executive branch locations were analyzed in section B.2., of this chapter.

Private sector.-A private sector location may reduce demands on the Government for materials information. supplement existing Federal systems, and promote private sector cooperation. But at the same time this location will not have the authority needed to carry out its primary mission to support public policmaking. may be incomplete and unreliable, will result in limited public and congressional access and use, and may be influenced by materials corporations or industries, Private sect o r mater i als information systems—especially with respect to scientific/technical information, clearinghouse/referral services, and forecasting/analytical capabilities in support of materials policymaking-might well be improved. perhaps through increased Federal [government support. But the private sector does not appear to be a feasible location for a major public policy-oriented alternative.

Public sector, Stale/local govcrnment.—Because the integrated capabilities are national and even international in scope, a State or local government location is not appropriate. However, State and local governments may contribute to and use the improved system, and may receive Federal support for development of their own systems.

Public sector, Fedcral legislative branch.-A legislative branch location for materials information activities will help Congress develop alternative sources of materials data and analyses, and ultimately strengthen the capability of Congress to reach informed and independent judgments on materials-related issues, But a principal location in the legislative branch will be subject to severe institutional and administrative limitations, will not be under the access requirements of the Freedom of Information Act (which does not apply to Congress), and will likely limit use by the executive branch and private sector, This location may also stimulate the burdensome use of congressional subpena power in obtaining materials data (if Government agencies do not cooperate voluntarily), and probably will not be able to provide adequate funding and personnel. Thus, while existing congressional committees and offices—CRS, GAO, CBO, and OTA—might we11 be upgraded a n d strengthened in the materials information area, in part through support of the congressional information system, the Congress does not appear to be a feasible location for a major alternative.

Public sector, Federal quasi-governmental organization. —A location in a Government-chartered corporation or Government advisory body will place responsibility within an independent institution, will be insulated from direct Government control, and therefore may enhance the credibility of data and analyses and increase the willingness of private companies to cooperate. However, a quasi-governmental location is not likely to provide the

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authority to acquire necessary materials information from Government agencies, and may impair the ability to operate effectively. This location will probably reduce responsiveness to Government and public needs, and will most likely preclude any significant use by the Congress. While a quasi-governmental organization may be suitable for supporting activities, similar to those suggested for a private sector location, it does not appear to be very feasible for an alternative designed to support actively the public policymaking process.

Public sector, Federal executive branch, - Thus the balancing of advantages and disadvantages clearly suggests the Federal executive branch as a principal location, although supporting or related materials information activities may be located in the private sector, State/local government, the Federal legislative branch, and/or quasi-governmental organizations.

To limit the executive branch possibilities to those consistent with the study focus, additional assumptions are that: (a) there will not be a massive reorganization of Government agencies, although arrangements such as a Department of Energy and Natural Resources could be considered; (b) there will be a distinct entity with some level of responsibility for achieving the integrated capabilities, including possible efforts to organize and integrate the existing Federal Government information systems; and (c) integrated capabilities will not have regulatory or policymaking responsibilities for substantive materials problems and issues.

Given the foregoing assumptions and evaluations of comparative advantages and disadvantages, the range of feasible and representative executive branch institutional locations includes (a) an existing office within an existing agency, (b) a new office within an existing agency, (c) a new executive agency, and (d) a new independent agency or commission. Each of these locations can then be combined with other important institutional components to create an overall institutional arrangement. These other institutional components include the following:

- scope of responsibilities with respect to the level of capability, e.g., referral, statistical, forecasting, and/or analytical, and the ability to make recommendations, promulgate rules and regulations, and take actions to carry out objectives;
- data collection and protection authorities with respect to the extent which existing authorities of relevant agencies will provide the basic framework, or whether new authorities will be needed and if so, to what extent will additional mandatory data collection be called for;
- data validation with respect to the extent which existing authorities will provide the basic framework, or whether new authorities and/or techniques with stronger provisions will be needed;
- data access with respect to the conditions under which the public, Congress, and the President will have access ;
- user charges; and
- oversight.

2. Selected Implementation Alternatives

Alternatives for implementing the integrated capabilities are derived from a combination of the appropriate legisla - tive/executive implementing options and institutional arrangements. Seven alternatives were selected to meet the following objectives:

- Represent a series of progressively stronger legislative/executive actions to organize and integrate the existing Federal Government materials information systems in order to meet policymaking needs for improved information;

- Through institutional change and systems improvement, add coordination and some centralization to the decentralized materials information systems now operative;

- Provide materials policy makers (both public and private) with aggregated materials information on a timely and convenient basis, but with sufficient checks and balances built in to protect against the abuse or misuse of the detailed (and frequently sensitive) data on which such information is based;

- Build upon, improve, and use more effectively (but not necessarily supplant) existing systems;

- Utilize where appropriate the outputs of State/local government and private sector materials information systems, without undertaking to organize and integrate non -Federal systems; and

- Provide Federal support for related improvements in State/local government and private sector systems, especially in the latter case with respect to scientific/technical information needed for materials R&D and engineering design,

The seven institutional arrangements summarized in tables VI–9 and VI–10 include:

1. Materials Information Referral Office,
2. Materials Information Coordinating Board,
3. Bureau of Materials Statistics,
4. Bureau of Materials Statistics and Forecasting,
5. Materials Statistics Administration,
6. Materials Statistics and Forecasting Administration, and
7. Materials Information Commission.

Arrangements 1 and 2 are representative of the level of incremental improvement and change and are consistent with systems approach A, coordinated evolution, Arrangements 3 and 4 are representative of the level of intermediate improvement and change and are consistent with systems approach B, step-by-step upgrading. Arrangements 5, 6, and 7 are representative of the level of maximum improvement and change. Arrangements 5 and 6 are consistent with systems approaches B and C. Arrangement 7 is consistent with approach C top-down change, except for the provisions for detailed data bases within the new institution. Without this provision it would be completely consistent. This was rejected as a viable systems approach because of the large amount of data and information systems already in existence. To duplicate these information systems would be very costly. In addition, it would be difficult to accomplish because of the lack of expertise and knowledge needed to collect and validate the data. The existing institutions are having problems obtaining the needed manpower for their own purposes. Table VI-10 shows which key components or information services are consistent or compatible with each institutional alternative and systems approach. Details for each institutional alternative are summarized in table VI-11,

Table VI-9.—Summary of the Institutional Arrangements

1. **Materials Information Referral Office:** To establish a materials information referral service (to be located in an existing agency) through which users can locate existing materials information and data bases.

2. **Materials Information Coordinating Board:** To establish a materials referral service, as in 1; to make recommendations and propose guidelines for improvement of existing materials information systems, coordination of existing systems, standardized reporting forms, data classification and protection, etc.; to facilitate the development of effective information interchange between existing agencies; and to provide support for private sector development of modeling/analytical, clearinghouse/referral, and necessary statistical/forecasting capabilities

3. **Bureau of Materials Statistics:** To establish an office or bureau (within an existing agency) which will include a materials information clearinghouse/referral service (through which users may locate and obtain materials information), a statistical capability (to provide summaries, trends, and statistics of historical and current materials data), and the necessary data processing/collection support; to facilitate the development of a summary materials data base to facilitate the development of effective information interchange between existing agencies; to provide for reliable and valid materials information through various methods of data verification (including, where necessary, submission of original data from relevant agencies; and to facilitate improvement in relevant activities of existing offices and agencies and private sector development of capabilities, as in 2.

4. **Bureau of Materials Statistics and Forecasting:** To establish an office or bureau (within an existing agency) which will include the clearinghouse/referral, statistical, and data processing/collection capabilities of 3, but with additional capability for materials forecasting/analysis; to facilitate the development of a summary materials data base and effective information interchange (between existing agencies), as in 3; to provide for methods of data verification, as in 3; and to facilitate improvement in relevant activities of existing offices and agencies and the private sector, as in 3.

5. **Materials Statistics Administration:** To establish a new executive agency which will include the clearinghouse/referral, statistical, and data processing/collection capabilities only (no forecasts, etc.); to facilitate development of a summary materials data base nd information interchange (between existing agencies), as in 4, but with additional authority to promulgate rules and regulations for improvement of existing systems, data classification, etc.; to provide for methods of data verification, as in 4, but with additional authority, where necessary, for direct validation of materials data at the original source; and to facilitate improvement in relevant activities of existing offices and agencies and the private sector, as in 4.

6. **Materials Statistics and Forecasting Administration:** To establish a new executive agency which will include ' the clearinghouse/referral, statistical, and data processing/collection capabilities of 5, but with additional capability for materials forecasting/analysis; to facilitate the development of a summary materials data base and effective information interchange (between existing agencies) with additional authority, as in 5; to provide for methods of data verification with additional authority, as in 5; and to facilitate improvement in relevant activities of existing offices and agencies and the private sector, as in 5.

7. **Materials Information Commission:** To establish a new independent agency or commission which will include the clearinghouse/referral, statistical, data processing/collection, and forecasting/analysis capabilities of 6; to facilitate the development of a summary data base, as in 6, but with additional authority for collection of materials data (superseding existing authorities of relevant agencies) so as to establish a detailed data base; to facilitate the development of effective information interchange (between existing agencies); as in 6; to provide for methods of data verification, as in 6; and to facilitate improvement in relevant activities of existing offices and agencies and the private sector, as in 6.

Note: Legal authorities for alternative 1-6 are not proposed to supersede those of existing agencies.

Table V1-10.-Summary of Key Components of Implementation Alternatives

	Materials Information Referral Office	Materials Information Coordinating Board	Bureau of Materials Statistics	Bureau of Materials Statistics and Forecasting	Materials Statistics Administration	Materials Statistics and Forecasting Administration	Materials Information Commission
Compatible with Systems Approach A							
Establish a materials referral service	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Improve relevant activities in legislative offices (e.g.. CBO, CRS, GAO) and executive agencies (e.g . Dol. DoC, DoA)	No	Yes	Yes	Yes	Yes	Yes	Yes
Upgrade Government support for private sector development of necessary capabilities	No	Yes	Yes	Yes	Yes	Yes	Yes
Establish effective information interchange between existing agencies	No	Yes	Yes	Yes	Yes	Yes	Yes
Compatible with Systems Approaches B and C							
Establish a new office/agency with clearinghouse/referral and statistical capabilities	No	No	Yes	Yes	Yes	Yes	Yes
Establish a summary materials data base in the Office/agency requiring submission of summary data from existing agencies	No	No	Yes	Yes	Yes	Yes	Yes
Provide the office/agency with data verification authority requiring, where necessary, submission of original data from existing agencies	No	No	Yes	Yes	Yes	Yes	Yes
Include forecasting/analytical capability within the office/agency	No	No	No	Yes	No	Yes	Yes
Provide a new executive agency with authority to issue rules and regulations and, where necessary, for direct verification of materials data at the original source	No	No	No	No	Yes	Yes	Yes
Compatible with Systems Approach C except for the datailed data base)							
Provide a new independent agency with authority for collection of materials data from original sources (superseding authority of existing agencies)	No	No	No	No	No	No	Yes
Establish a detailed materials data base in the independent agency	No	No	No	No	No	No	Yes

2 Materials Information | 3 Bureau of | 4 Bureau of | 5

	1 Materials Information Referral Office	2 Materials Information Coordinating Board	3 Bureau of Materials Statistics	4 Bureau of Materials Statistics & Forecasting	5 Materials Statistics Administration	6 Materials Statistics Forecasting Administration	7 Materials Information Commission
Location	Existing or new office within existing agency	Existing or new office within existing agency	New office within existing agency	New office within existing agency	New executive agency	New executive agency	New independent agency or commission
Directorship	Existing (parent) agency should afford sufficient opportunity to develop and/or acquire the necessary resources, competence, credibility, and reputation.				None	None	None
	Director appointed by agency or office head	Chairman and members selected from agencies & user groups, may be appointed by President	Director appointed by President with Senate advice and consent	Director appointed by President with Senate advice and consent	Administrator appointed by President with Senate advice and consent	Administrator appointed by President with Senate advice and consent	Commissione[rs] appointed by President fo[r] fixed terms o[f] office wit[h] Senate advice and consent
Source of Authority	OMB directive, Executive/agency order, and/or Act of congress	OMB directive, Executive/agency order, and/or Act of Congress	Act of Congress	Act of Congress	Act of Congress	Act of Congress	Act of Congres[s]
General Authority	The general scope of authority for all alternatives includes the acquisition and analysis of information and related data processing/collection support necessary for implementation of designated capabilities and options in areas relating to materials/commodities and supply/utilization life cycles, including secondary factors (e.g., labor, capital, energy, environment, price, technology, and transportation) and interrelationships (e.g., between materials, energy, and the environment)						
		Authority to make recommendations (and take actions, to the extent possible under applicable law) for improvement of existing Federal Government materials information systems, coordination and integration of existing systems, standardization of existing systems, improvement of reporting forms and data classification, etc. Authority to provide support for private sector development of capabilities and services necessary.					
					Authority to promulgate rules and regulations to carry out the above activities		
Specific Authority: Capabilities	Referral	Referral	Referral Clearinghouse Statistical	Referral Clearinghouse Statistical Forecasting/analytical	Referral Clearinghouse Statistical	Referral Clearinghouse Forecasting/analytical	Referral Clearinghouse Statistical Forecasting/analytical
Data Collection and Protection	[Re]ly primarily on the existing authorities of relevant agencies (usually a mix of voluntary and mandatory ...c to existing pro[te]ctions of data sources and trade secrets and other proprietary, confidential, or privileged						
			Authority to require that relevant agencies submit summary data (in aggregated form) to the office/agency, subject to existing or new protections of data sources. Authority to collect original data that is not otherwise available from existing sources.				
					Authority to promulgate rules and regulations for collection of original data by other agencies.		
							Authority to require that agencies submit detailed data
	...y substantially on the existing authorities of relevant agencies, subject to existing protections of data						
			Authority to use statistical techniques, sampling, and other methods ... and where necessary, to require ... undertake, where necessary, direct ... subject to existing or new protec[tions] of materials data at the original source ... to new or existing protections				
Data Access	The Freedom of Information Act (FOIA) sets the basic guidelines for access to data in all configurations. Data/information not falling within an exempted category would be available to the public, Congress, and the President either directly from the office/agency and/or, in the case of Congress, via the CBO (or some other lead congressional office) and, for the President, via OMB (or some other lead executive office).						
User Charges	The Freedom of Information Act also sets the basic guidelines with regard to user charges for public access, which may be no greater than the cost of search plus reproduction. In general, there would be no charge for standard referral services, with the charge for other services no greater than the cost of search plus reproduction. Special services for other agencies or private users may be charged on cost-reimbursable or subscription basis.						
Oversight	All configurations would be subject to normal oversight of OMB and congressional committees, supplemented by GAO (which would be required to maintain continuous monitoring of office/agency activities, in addition to any investigators or data validations requested by Congress).						

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Chapter VII

ANALYSIS OF POSSIBLE IMPACTS

Chapter VII

ANALYSIS OF POSSIBLE IMPACTS

The range of possible impacts of improving the flow of materials information and analysis to public and private decision-makers is extremely wide. This assessment focuses on five broad impact areas judged to be most significant: Government, the economy, social institutions and behavior, international policy-making, and public law.

The impact analysis suggests the following conclusions:

- **The potential impacts of improvement in organization and integration of materials information systems in the Federal Government appear to be primarily beneficial, and the likely detrimental impacts in large measure are avoidable, controllable, or justifiable in the public interest.**
- **At the incremental level of improvement and change, all impacts appear to be minimal or marginal. Benefits appear to be of major or overriding significance, and costs appear to be negligible.**
- **At the intermediate level of improvement and change, many impacts could become significant. At this level and above, some of the potential impacts appear to be critical or of overriding importance relative to other trends in society, the Government, and the economy. And even those impacts which in the short-run are marginal or minimal may assume cumulative importance over time. Overall, potential benefits are judged to substantially outweigh any potential detrimental impacts.**
- **At the maximum level of improvement and change, several impacts could be very beneficial. However, at this level the possible detrimental impacts or costs could be significant enough to warrant very careful consideration of the trade-offs involved.**

A. INTRODUCTION

The range of possible long-term effects of improving the flow of materials information and analysis to public and private decision-makers by establishing the integrated capabilities is extremely wide. This assessment focuses on five broad impact areas judged to be most significant, at least from the standpoint of national decision makers: the Government, the economy, social institutions and behavior, international policymaking, and public law.

To simplify the analysis where appropriate, institutional arrangements 1 and 2 (the Materials Information Referral Office and Materials Information Coordinating Board) will be considered together as institutional arrangements at the level of incremental improvement and change. Likewise, institutional arrangements 3 and 4 (the Bureau of Materials Statistics and Bureau of Materials Statistics and Forecasting) will at times be discussed together as institutional arrangements at the level of intermediate improvement and change. Finally, institutional arrangements 5, **6,** and **7** (the Materials Statistics Administration, Materials Statistics and Forecasting Administration, and Materials Information Commission) will frequently be considered together as institutional arrangements at the level of maximum improvement and change.

B. IMPACTS ON GOVERNMENT

Basic conditions and key trends determining the impacts on governmental processes include (a) the increasing complexity and criticality of materials supply and demand in a highly industrialized society, (b) the concomitant need for detailed information and statistical analysis, and (c) the importance of long-range forecasting to support contingency planning and materials policymaking,

In the area of governmental impacts, the potentially significant effects identified were:

- Support for governmental planning and priority selection;
- Increased ability of decisionmakers to cope with materials problems;
- Possible improvement in relationships between Federal, State, and local governments;
- Changes in the distribution of influence and responsibility among Federal agencies; and
- Support for increased public participation in decisionmaking.

1. Support for Governmental Planning and Priority Selection

Improving existing information systems could contribute needed support to the process of planning, definition of objectives, and priority selection with respect to materials policy. The importance of this contribution is very significant, although information is only one of many variables in the planning process, Acceptance and utilization of such improvements could take time to build. At the level of incremental improvement (systems approach A), impacts could be minimal because many responsible Government officials already are informed about available information and have established contacts with the collecting agencies. Thus, the Materials Information Referral Office could at most contribute some added convenience when new kinds of information are needed by an individual official. The Materials Information Coordinating Board, by adding more extensive improvement to collection/analysis activities in other agencies and the private sector, could marginally upgrade the quality and availability of information.

At the intermediate level of improvement (systems approach B), the Bureau of Materials Statistics could provide substantial benefits in terms of speed and convenience in procuring data and providing a more consistent statistical base for varied elements and sources of policy-making. The addition of forecasting capability through the Bureau of Materials Statistics and Forecasting could greatly increase potential benefits to governmental planners by permitting more consistency in the assumptions used for long-range planning by various agencies and the legislative branch, and could contribute to broader consensus on materials-related policy issues. The Bureau could provide a focus for the organization and integration of existing Government materials information systems, and could permit application of the materials cycle concept to support the policy-making process, On the other hand, if the statistical analysis function reveals disparities between actual resource allocation and relevant values held by interest groups, policy makers, or large segments of the public, there could be a short-range increase in political tensions and conflict as a result.

The arrangements involving maximum change (systems approach C), add to the potential benefits through stronger authority to validate data at the original source, How much benefit depends on the extent to which present data collection is found to be unreliable or misleading. The Materials Statistics Administration, although probably providing a large increase in the volume of statistical data (and forecasting and analysis for the Materials Statistics and Forecasting Administration) could detract from the policy-related activity in other agencies and locations by competing with them or aggregating from them some of the necessary supporting activities, However, the lack of forecasting and analysis functions in the Materials Statistics Administration, while perhaps minimizing disruption of related activities in existing agencies, may severely constrain its usefulness.

Thus there are trade-offs to be made in evaluating the relative benefits of this level of change. Whereas the Materials Information Commission might be more independent of executive branch policy constraints and thus be more useful to or more trusted by Congress, this same independence could lead to its removal from the mainstream of policy-related activities and cause duplication of many of its functions within both executive and legislative agencies and support organizations.

2. Increased Ability of Decisionmakers To Cope With Materials Problems

The ability of Federal-level decisionmakers to cope with materials-related problems depends in part on the quality and availability of information. Also significant are the availability of alternative materials and technology, the authority and responsibility of the Government to intervene in economic transactions, the public acceptance of such interventions, and the external restraints represented by the action of other nations or the degree of cooperation achieved domestically by industry and consumers. Thus, improvement in information flow could contribute significantly to the capability of understanding and analyzing problems and issues and also could aid in the ability to achieve solutions (e.g., with respect to the materials, energy, environmental and transportation implications of possible substitutes for imported aluminum or the development of solar-energy sources in the Southwest). Therefore, possible impacts on the solution of materials-related problems are closely parallel to the potential impacts on planning and priority selection. The forecasting and analysis functions which are included in the intermediate and maximum levels of improvement could afford significant benefits in situations where understanding of the scope and complexity of a problem (and its social, political, and economic implications) is essential, and where consensus must be reached quickly in key areas (e.g., reacting to a political crisis such as the oil embargo). In longer range problemsolving, where responsible officials are assumed at present to do their own forecasting and analysis, the benefits would again be in terms of the quality of analysis and consistency of forecasts.

3. Possible Improvement In Relationships Between Federal, State, and Local Governments

Impacts of improved materials information flow on intergovernmental relations probably will be significant, with most benefits likely to accrue to State and local planners and decisionmakers, especially in smaller States and localities with least internal resources for information gathering, analysis, and forecasting. At the incremental and intermediate improvement levels, State and local planners and decisionmakers could derive substantial benefits from the added convenience and ease of locating data in Federal agencies or in a new office or agency. And, they could benefit by the analysis and forecasts made available to them, as well as the support provided for improvement of their own data capabilities. This could enhance cooperation between levels of Government to the advantage of both. At the maximum change levels, these benefits could be outweighed by distrust or resentment resulting from activities arising through the additional authority to verify and validate data, from resistance to growth in the Federal bureaucracy, and possibly from disruption of established contacts in the existing Federal agencies,

4. Changes in the Distribution of Influence and Responsibility Among Federal Agencies

The distribution of influence, responsibility, power, and public visibility among Federal agencies will also be impacted by improvements and changes in materials information systems. Hence, indirectly, the oversight functions of some congressional committees will be affected as well as budgetary allocations to the affected agencies. These changes are of little interest to information users and to the public, but they may be of concern to Congressmen and are very important in determining the stance of agencies toward proposed changes in existing systems. Some impacts could be manifested even at the incremental level of change.

For the Referral Office, impacts could be confined largely to the parent agency which must establish and maintain the referral system, and to other agencies which will be asked to respond to the referrals themselves. This impact is limited to the need for new positions and support facilities, and to some incremental increase in public visibility and constituency for the parent agency. The Coordinating Board adds to the referral system the effort necessary for more extensive improvement of information systems in other agencies plus governmental support for improvement of private sector systems. Thus, there could be increased costs as well as benefits for other agencies, benefits (subsidies) for industry and possibly for universities and research organizations, and general public benefits from improved accessibility and quality of information.

At the intermediate level, the Bureau of Materials Statistics (or Materials Statistics and Forecasting) could represent a significant impact (increased responsibility and benefits) for the parent agency and some diminution of responsibilities, constituency, or budget for other agencies who will, however, still have their existing responsibilities for data collection and dissemination. At the maximum change level, however, creation of a new executive agency (an Administration for Materials Statistics or Materials Statistics and Forecasting) might create a new force in materials-related activities and constitute a significant loss of functions, influence, personnel, and constituency for existing agencies, Furthermore, the additional authority to validate data and determine procedures and classifications for its collection could create new demands and checks on other agencies, which will nevertheless still retain data collection functions, The Materials Information Commission is vested with authority to collect data, superseding some of the functions of other agencies. This institutional arrangement could obviously have the most significant impacts. All arrangements within the maximum change level (and probably the intermediate level as well) require new legislation and thus could require new oversight and budgetary activities in Congress.

5. Support for Increased Public Participation in Decisionmaking

Conflicts between the public demand for information and the demand for protection of proprietary information on the part of industry could very likely arise,

At the incremental level of change, there could be small but beneficial impacts on public participation since a referral service (and, to a lesser extent, improvement in private information systems) could primarily benefit the public and private interest groups who lack the established contacts and relatively easy access to sources of information which governmental officials by and large already enjoy. The costs of providing this service to the public could be significant over time. Federal decisionmakers may reap secondary benefits, however, if informed participation is less apt to be suspicious, hostile, or counter to established governmental objectives than less informed participation. On the other hand, more available information may stimulate public interventions through court suits and administrative proceedings. Both possible outcomes are increasingly likely as statistical aggregation and analysis and official forecasts are made available (at the intermediate change level) and as the source of such information is more publicly visible (at the maximum change level, with a new executive or independent agency). The possible conflict between public demands for information, operating through the Freedom of Information Act, and the need for protection of confidential data and information sensitive to industry planning could become more acute at the intermediate and maximum levels, as stronger authority for verification of data is added.

C. IMPACTS ON THE ECONOMY

Among the possible economic implications are:

- Improved ability of the private sector to meet national needs for materials;
- Clarification of materials substitution and R&D options;
- Support for industrial planning;
- Changes in the competitiveness of the materials industry;
- Stimulus to governmental/industrial cooperation in materials policy development and implementation;
- Clarification of consumer choices; and
- Contribution to land use and regional planning.

Basic economic conditions and trends include the new concern about the ability of industry to meet national needs under possible conditions of limited resource availability, and new realization of the extent to which raw materials have become dependent on foreign sources. In addition, during the last decade pressure has developed to force industry to absorb what were hitherto regarded as external costs: environmental pollution and social welfare responsibilities, To the extent that reliable information is lacking, including credible statistical analysis and forecasts of supply and demand, standards and criteria may indeed be established which cannot be implemented or enforced or which place unreasonable burdens on some segments of the economy.

1. Improved Ability of the Private Sector To Meet National Needs for Materials

Adequate information is essential both to industry and to Government in trying to maintain the most productive balance between the basic role of industry in supplying raw materials and finished goods, and the responsibility of Government to support, regulate, and in some cases subsidize these activities. Industry is constrained in information gathering in four ways: (a) by its own resource limitations; (b) by the complexity and diffusion of Federal processes of information gathering and analysis (and policymaking, implementation, and related regulatory activities); (c) by the necessity of protecting proprietary information whose release would compromise the competitive position of individual corporations; and (d) by constraints imposed by antitrust legislation against the sharing of information, forecasts, and planning activities. The Government, however, can ease some of these constraints by centralizing and aggregating data in such a way that information affecting the competitive position of individual companies is protected.

At the incremental level of improvement of materials information systems, no additional data gathering is envisioned. Industry (in general) has established knowledge and sources of information so that a Materials Information Referral Office adds few benefits. Some assistance to the private sector and to agencies in improving data collection and classification is included within the mandate of the Coordinating Board, so with this alternative there could be small, long-range beneficial impacts. The additional statistical analysis and forecasting included at the intermediate level (the Bureau of Materials Statistics or Materials Statistics and Forecasting) could add significant beneficial impacts by providing industry with better information about the analytical basis and assumptions underlying evolving governmental policy, as well as supplementing the similar analyses carried on within the private sector.

At the maximum change level, a new executive branch agency could have stronger authority for verification and validation of data (and the Materials Information Commission would in addition have authorization for collecting data). At this level, the possibilities of conflict over protection of sensitive information, and the possibility of accidental or deliberate disclosure of such information to the detriment of corporations, could become acute, and new legislative safeguards would likely be needed.

To protect against the possibility of abuse of information or of excessive control over information, institutional arrangements at the maximum change level (the Materials Statistical Administration and Information Commission) are envisioned as having a number of checks and balances. The Freedom of Information Act assures that aggregated data will be available to all. Direct and continuous oversight by GAO and OMB and periodic review and investigation by congressional committees are provided, Except perhaps for the independent commission, all proposed arrangements could retain primary data collection activity in existing agencies, continuing the safeguards now provided by their charters and enabling legislation, In general, therefore, improvement of existing information systems could provide additional support to industry in meeting national materials needs, The improvements could significantly contribute to industry's capability in this area.

2. Clarification of Materials Substitution and R&D Options

Materials substitution requires effective forecasting of availability and costs; it also requires information about materials performance, Research and development programs may be necessary and must be initiated well in advance of critical needs. A flow of materials information, including both technical information and identification of ongoing R&D, is important to this process and has important implications for governmental policy makers as well as industry.

At the incremental improvement level, benefits could be relatively small but could still have long-range importance because of improvement of existing information systems (stimulated by the Coordinating Board), At the intermediate and maximum change levels, benefits could be much larger because of the added consistency and scope of statistical analysis of rates of development and consumption and forecasts of availability. The requirements for analysis and forecasting that would be provided by the Bureau of Materials Statistics and Forecasting, the Materials Statistics and Forecasting Administration, or the Materials Information Commission could be used to alert industry to impending governmental demands and constraints in time to incorporate this information into long-range corporate planning and investment strategy, The authority to validate information included in the arrangements for a new Administration or Commission, as applied to ongoing research and development and anticipating technological breakthroughs, could pose a particular threat to industry and require well-considered legislative safeguards as a part of any enabling legislation.

3. Support for Industrial Planning

The impacts on corporate planning are potentially important. Industry must now take into account a range of considerations far more extensive than the traditional criteria of profitability: national and international policies, worldwide economic fluctuations, political stability in developing countries, environmental and social impacts, consumer reactions, and changing employment patterns, among others. The development of technological forecasting since World War II is more recently being paralleled by corporate interest in social and policy forecasting. In these activities, as will be further discussed below, large corporations have a great advantage over smaller companies. Yet small companies may be particularly important to meeting national needs, especially in the area of exploring and opening up new materials sources and in innovation and technological breakthroughs, Improvements in materials information systems at the incremental level could have some benefits for small suppliers but little for larger corporations with an established capability for using all available sources of data.

At the intermediate level, benefits could also be proportionately larger for small firms with little capability for statistical analysis and forecasting. But at this level and above, benefits could also become significant for larger companies and multinationals by allowing them to mesh their own assumptions and planning with governmental forecasts of national needs, Direct benefits to governmental decisionmakers could also become significant because this meshing will facilitate implementation of stockpiling and long-range procurement planning. Clarification of the possible need for Government-stimulated or subsidized R&D could allow more efficient long-range allocation of research budgets, Again, however, validation of data as related to industrial investment planning requires sensitive legal safeguards.

4. Changes In the Competitiveness of the Materials Industry

As indicated in the discussion of industrial planning, the disadvantages of small firms relative to large firms could tend to decrease by improving their access to existing data sources (at the incremental change level) and by supplying basic statistical analysis and forecasts (at the intermediate and maximum change levels), Indirectly, on the other hand, the tendency to use the same basic forecasts and analysis, as supplied by the institutional arrangements with these capabilities, could to some extent have the same effect as collusion among the giant industries in the field, and could discourage small firms from high-risk ventures which they might otherwise undertake. At the maximum change level, the creation of a new Administration or Commission might intensify industry fears of centralized governmental planning and intrusion of Government into the private sector. There is also, allied to the new authority to validate data, an increased possibility of efforts to influence governmental officials for purposes of abuse of confidential information.

5. Stimulus to Governmental/Industrial Cooperation in Materials Policy Development and Implementation

These potential impacts also relate to Government and industry cooperation in materials policy development and implementation, The traditional view has been that extensive cooperation was not desired and was indeed suspect except in defense and heavily regulated industries, The long-range trend, however, is toward increasing interdependence of the public and private sectors in deci - sionmaking because of the pressure on resources, the growing complexity and interrelatedness of the national economy, and the increasing costs of technology and of research and development. Public pressure and the need for an image of social responsibility have also brought about decreased resistance by industry toward absorbing what were hitherto considered externalities or social costs.

Aside from the benefits of governmental assistance in improving existing public and private sector information systems at the incremental change level, there will be an additional stimulus to business/Government cooperation through the shared use of assumptions based on the statistical analysis and forecasting capability of the Bureau of Materials Statistics and Forecasting, the Materials Statistics and Forecasting Administration, and the Materials Information Commission, The use of the materials cycle concept as the focus of analysis at the intermediate and maximum change levels, for example, is a rich basis for governmental/industry cooperation in policy formulation to the advantage of both, As already noted, however, the perception of increased governmental activity and involvement in materials supply/demand planning may in some industrial quarters raise strong fear of increased constraint and regulation and loss of the advantages of confidential information.

6. Clarification of Consumer Choices

Improvement or change in materials information systems should have little significant direct impact in the area of consumer behavior, other than to clarify choices. There is increased sensitivity to health, safety, and environmental impacts on the part of consumers, and increasing selectivity among products on the basis of rising costs, But consumer choices are determined by many variables, and detailed information about materials is probably an important factor only in a small minority of cases, Establishment of a Consumer Protection Agency which might draw on the materials information either through the referral service or the clearinghouse function could increase impacts somewhat; otherwise, use of the information by individual consumers will probably not be large, except perhaps with a small group of highly motivated and informed consumers,

7. Contribution to Land Use and Regional Planning

The impact on land use and regional development could be significant in development of land use plans, Land use planning is steadily increasing as the long tradition of emphasis on growth has come into conflict with environmental concerns (and rising land prices). Wise land use planning includes consideration of the relative desirability of alternative uses, including minerals development. However, materials needs at the national level, regional objectives for economic development, and local environmental values imply complex trade-oft's which must be adjudicated or mediated between public and private sectors, different regions and States, and different levels of Government.

Impacts at the incremental level of improvement could be minimal, resulting only from additional convenience in locating data by local officials (who are generally already informed about existing sources) and improvement in agency and regional or private sector information systems. At the intermediate and maximum change levels, statistical analysis capability could be of significant assistance, as could forecasting. But in the latter case, local authorities are apt to treat national forecasts skeptically where such forecasts conflict with local perceptions or priorities. The new Administration or Commission proposed in the maximum change levels could have minor short-range detrimental impacts by disrupting established contacts between agencies and local authorities,

D. SOCIAL IMPACTS

In the area of social impacts, the following potential effects were identified:

- Improved materials information management;
- Increased access to materials information;
- Concern over privacy (individual and corporate) and control of information;
- Movement toward futures research and interest in alternative futures;
- Media treatment of materials-related national problems;
- Public understanding of materials-related national problems; and
- Education and curriculum development in materials-related areas.

1. Improved Materials Information Management

At the incremental change level, the Materials Information Referral Office could provide only marginally additional ease of access to information/materials specialists who already have established access to existing sources of data. Improvement in agency materials information systems and private sector systems could be supported by the Coordinating Board, and could be beneficial, as could the statistical analyses and forecasts available through various institutional arrangements for intermediate and maximum change. The authority to validate data and collect additional data (at the intermediate and maximum levels) could add to the information load of all existing systems and must therefore be counted both as a benefit and a cost.

2. Increased Access to Materials Information

Access to information has become more important as the demand for public participation in decisionmaking (through hearings, law suits, and other modes of public intervention) has increased. Under the access policies represented by the Freedom of Information Act, any improvement in existing systems beginning at the incremental change level, could mean progressively larger demand for service to the public at large, especially to public interest groups. Public demand could be further stimulated by the higher visibility inherent in a new Bureau or Administration at the intermediate and maximum change levels. This service may be costly. As already noted, the statistical, forecasting, and analysis capabilities could also increase demands for full access from the industrial and research sectors and from other Government agencies. To some extent, however, demands on existing agencies could be relieved at the intermediate and especially at the maximum change levels, although demands might be increased over present levels at the incremental change level as the referral service could tend to stimulate requests for access to agency information.

Improved access to information in the sense of quality and scope of data could increase significantly at the intermediate and maximum change levels. Through validation of data presently provided by the private sector and by the authority to collect new data independent of existing sources, the maximum change alternatives (new Administration or Commission) could offer the prospect of the greatest improvement in the quality as well as the level of access.

3. Concern Over Individual and Corporate Privacy and Control of Information

Privacy and control of information is a sensitive area of potential impact. The increasing use of integrated, computerized data banks has led to great concern over the possibility of abuses and to attempts to provide legal safeguards (e.g., the Privacy Act of 1974), Personal privacy is unlikely to be affected by any currently proposed changes in materials information systems. There are possible impacts on corporate privacy (control of “proprietary” information), but these are not relevant at the incremental level of change, However, the actions of the Coordinating Board could, over time, lead to redefinition of classification and standards of data collection by stimulating and supporting incremental improvement in existing information systems. Danger to corporate privacy is minimized in arrangements creating a new Bureau or Administration. While there is added authority to validate raw data collected by Government agencies, the original authority and responsibility for collection of data remains in existing sources. Those Government agencies which now collect, aggregate, and disseminate data will continue to do so under laws and regulations which appear to provide adequate safeguards.

The authority to validate information at the original source, which is added in the maximum change level (a new Administration or Commission), is the first of two sensitive points. Some safeguards against erosion of corporate privacy are assumed. Application of safeguards in existing statutes (the Freedom of Information Act and the Privacy Act). direct monitoring by OMB and GAO, oversight by congressional committees, and court action. Protection can be built into the systems technically, but additional legal safeguards may be needed, The second sensitive point is the authority provided for the Materials Information Commission to collect new data independently of existing sources and maintain a detailed data base, This data bank may well expose information presently held only by private sector corporations and considered confidential. Aggregation of data may not be sufficient to prevent some detrimental impacts on corporate competitive positions (or public image), and careful trade-offs will have to be made between public and private interests in this area.

A related impact area is possible stimulation of the growth of interconnected data banks and retrieval systems. These impacts could be minimal at the incremental change level, although the Referral Office could be interconnected with search and retrieval systems in the public and private sectors, and thus stimulate wider use of such systems, Improvement of existing materials information systems through actions of the Coordinating Board could have a similar stimulating effect, and in fact could be necessary before interconnection between agency information systems (now in early stages of discussion or development) is thoroughly feasible.

The summary data bank envisioned for a new Bureau (at the intermediate change level) or for a new Administration (at the maximum change level), and even more specifically the detailed data base to be developed by the Materials Information Commission, could ultimately have direct access to and from agencies. Given the summary data base, interconnection between the new agency, executive and congressional policymaking, and policy analysis offices (OMB, CBO, OTA, GAO, CRS, and even congressional committee offices), or between the new agency and State and local agencies and Federal field offices appears feasible, The detailed data base envisioned under the Commission arrangement could make such interconnections a necessity.

4. Movement Toward Futures Research and Interest in Alternative Futures

Futures research and public attention to the discussion of alternative futures for the United States is a growing movement deriving from wide perception of an increasing rate of social change and uncertainty about conditions perceived as outside individual control. This policy-oriented attention to future options began in academic/professional/research circles (as evidenced by the rapid growth of the World Future Society, and the establishment of a number of "futures" journals). More recently it has begun to be institutionalized in the Federal Government (CRS has a futures study group, and congressional committees are now required to give increased attention to futures options). A number of States have established commissions or committees to conduct analysis or lead discussions of alternative futures for the State or region.

The impacts on the movement toward deliberate design of future options (both within the Government and in the larger public forum) could become significant over the long range. This is most likely at the intermediate change level with the addition of forecasting capability (the Bureau of Materials Statistics and Forecasting), and especially with the added visibility gained through the establishment of a new Administration or Commission at the maximum change level. Emphasis on the materials-cycle concept could also help to raise the level of discourse on alternative futures.

5. Media Treatment of Materials-Related National Problems

Media treatment of materials-related national problems is increasing, but is often marked by a lack of depth and sophistication or by polemical rather than balanced analytical treatment. The media are perhaps the major stimulators of political debate in the United States and often serve to identify emerging national problems, at least for the public, to influence or constrain the definition of policy issues, to inject expert or scientific opinion into the public discussion, and to educate the public about possible responses (e.g., energy conservation). Increasingly, a portion of the print media is becoming specialized to meet the demands of the newly concerned public for information about emerging national problems (e.g., environmental affairs journals, consumer affairs journals).

While improvement of materials information systems would support media attention to materials-related problems, this impact could perhaps assume immediate significance only at the maximum change level. Here, the establishment of a new Administration or Commission could focus media attention on materials problems with a newsworthy event, and over time the media could tend to develop media specialists to deal with that agency. At the intermediate level of change, however, there could be longer range development of margin a 1 impacts because the media, especially the specialized print media, could tend to use materials statistical analyses, forecasts, and analyses only to a limited extent, However, the materials-cycle concept alone, if picked up by the media, could itself lead to a new organizing principle or framework for materials-related public affairs programming.

E. IMPACTS ON INTERNATIONAL POLICYMAKING

The following areas of possible international impact were identified:

- Awareness of need for international materials information;
- Operation of multinational corporations;
- Increased ability to cope with international materials cartels;
- Improved basis for foreign policy on materials and trade;
- Stimulation of the use of satellites for information purposes; and
- Support for international discussion of materials-related problems.

1. Awareness of Need for International Materials Information

Awareness of the need for international materials information will be increased by improving materials information systems. Historically, the advanced industrial nations have acquired much of their raw materials from less developed nations. International policy has been oriented toward protecting American foreign investment. But the post-World War II rise of nationalism, and rising resentment over the gap in standards of living between developed and developing nations, has decreased the relative economic leverage of the United States. Developing nations are exerting control over their resources through nationalization of foreign investments, cartels, tax policies, and so forth, The U.S. policy is moving toward commodity agreements rather than a free trade posture, Multinational corporations already benefit greatly from their access to information about materials in many countries, but other U.S. industries as well as the U.S. Government have an increasing need for foreign materials information,

At the incremental level of improvement, benefits could accrue more to foreign governments and corporations (to the extent that they can use the referral service) than to U.S. industry. Even if there is exchange of information, the United States probably maintains more comprehensive materials information than most other countries. At the intermediate and maximum change levels, however, the clearinghouse function could make it significantly easier for U.S. industry as well as policy makers to obtain information about many countries from one source. The data could also be incorporated into statistical analysis and forecasting, A new Bureau, Administration, or Commission (and perhaps even the Coordinating Board) could have some authority or, at the minimum, influence to improve categorization and classification of national security information related to materials. This may have the long-range result of declassifying some information currently not available to the public or even to civilian analysts and policy makers. However, should foreign governments and industry be reluctant to provide information, the net effect could be to the disadvantage of domestic competitive interests, This might in turn generate proposals for limiting foreign access to information.

2. Operation of Multinational Corporations

In the area of materials, many multinational corporations have scope, resources, and scale second only to national governments, Improving the materials information systems is likely to have little impact on the operations of the multinationals, or little benefit for them, except that by checking their own forecasts and analyses against that of an integrated systems, they may have a common basis for planning and for reacting to crisis in conjunction with or as a response to national policies. In a sense, this could benefit multinational corporations by making the "rules of the game" more explicit. However, the more significant impacts may be benefits to U.S. policy makers in increasing their capability to understand the operations of multinationals.

3. Increased Ability to Cope With International Materials Cartels

There may also be impacts on the formation and operation of international materials cartels (combinations of suppliers with control over supply and/or price of materials). The OPEC experience has led to fears of similar actions in regard to other materials for which the United States is dependent on less developed countries, for example, the pricing actions taken by the International Bauxite Association. Improved requirements for statistical analysis and forecasting and for gathering and validating information (at the intermediate and maximum change levels) could assist in developing strategies and contingency plans for coping with these situations in advance of their occurrence.

4. Improved Basis for Foreign Policy on Materials and Trade

Linkages of materials policy with foreign policy and national security policy are critical, involving the need for information about alternative foreign sources of materials, the effects of technology transfer, and foreign aid. Other areas of concern include stockpiling needs, substitution possibilities from domestic sources, trade and investment patterns, and the potentials of conservation and recycling. Again, integrated capabilities for statistical analysis and forecasting and for validating information could provide significant assistance at the intermediate and maximum change levels, and the use of the materials cycle concept may become a useful basis for preparing for international negotiations about materials and trade.

5. Stimulation of Use of Satellites for Information Purposes

The use of domestic and international satellites for developing materials information may receive some stimulation from establishing the integrated capabilities and the authority to validate information at the maximum change level, Remote sensing, including the Earth Resources Technology Satellite (ERTS)—now called LANDSAT—is chiefly useful for cataloging above-ground resources. This technology has aroused international controversy over possible erosion of control over national resources by less developed countries, Use of satellite technology by a highly visible new Administration or Commission to validate existing data or gather new data could increase the fearful perception by other countries of increased U.S. control over information to serve our own purposes, However, the benefits of international use of ERTS could be strengthened by improved data criteria and classification and by widespread use of the concept of the materials cycle as a structuring principle.

6. Support for International Discussion of Materials-Related Problems

The United Nations' Organization for Economic Cooperation and Development, and other international organizations (including nongovernmental organs such as the International Institute for Applied Systems Research and the Society for General Systems Research) are increasingly active in the area of materials information and related educational activities.

For example, in 1974, the UN sponsored a Sixth Special Session on "Raw Materials and Development, " and OECD is currently surveying member countries on materials policy and R&D priorities, It is likely that international discussion of materials-related problems could be supported by and also contribute to data incorporate in the integrated capabilities.

F. IMPACTS ON PUBLIC LAW

The possible legal impact areas considered include:

- Submission of materials information by private sources and validation of materials data by Government agencies;
- Exchange of materials information by Government agencies;
- Application of the Freedom of Information Act to data in materials information systems;
- Revision of reporting requirements for materials-related industries; and
- Promotion of other national policies and programs.

1. Submission and Validation of Materials Data

At present, Government agencies rely primarily on voluntary compliance with their requests for materials data by private sector sources. While many agencies possess the authority to compel reporting of materials data, few agencies are vested with full power to obtain validation of data submitted beyond mere visitational authority.

In recent years, recognition of the effects of corporate activities on national interests has led to new reporting and disclosure requirements on private industry, such as those found in environmental and safety legislation (e.g., the National Environmental Policy Act and the Occupational Health and Safety Act) as well as economic and energy legislation (e.g., the Economic Stabilization Act, Federal Energy Act, and the Energy Supply and Environmental Coordination Act). Such legislation deliberately confers extensive investigatory and enforcement power upon relevant agencies, and some of the current legislative proposals for materials information systems could continue this trend,

No change in existing agency mandatory authority is contemplated at the incremental and intermediate change levels (Referral Office, Coordinating Board, or New Bureau). Consequently, no direct impact could arise from implementing these arrangements. However, some minor indirect impacts may result from establishing a Coordinating Board or new Bureau, as changes in agency data collection practices are made to accommodate the needs of the information systems and as increased and more detailed requests for information are sought from the materials industry, Any reluctance by industry to comply voluntarily may cause agencies to exercise existing authority to compel disclosure and validation and to seek additional mandatory power where necessary,

Institutional arrangements at the maximum change level (a new Administration or Commission) call for expansion of Government authority to validate data submissions at the original source. In addition, as at the incremental and intermediate change levels, increased use of existing powers of relevant agencies may be expected as the integrated capabilities are developed, with expansion of other agencies' mandatory authority (a possibility in the face of any damaging noncompliance by industry).

Authority of the Materials Information Commission could actually supersede the authority of existing agencies for data collection and validation, thus consolidating most statistical responsibilities in a single agency. However, this would not necessarily mean a further increase in the collection and validation powers of the Government, since the actual data collection could remain primarily with existing agencies and could be subject to existing protections of data sources.

2. Exchange of Materials Information by Government Agencies

Under existing institutional arrangements, many different Government agencies are involved in the collection and analysis of materials information, resulting in duplication of information and discouragement of cooperation between agencies. Some efforts have been made to eliminate a portion of this costly overlap. However, many existing laws, regulations, and practices create absolute barriers to sharing of information between agencies,

The commodities information program administered by the Department of Commerce illustrates the problems of interagency cooperation. Commodities statistics are collected and analyzed by various offices in the Departments of Commerce, Agriculture, and Interior. Additional economic information is obtained from the Departments of Labor and Treasury. All of this information is then used by the Department of Commerce in its economic publications and analyses. But other agencies seeking data used in compilation of these reports have limited access, and must obtain the necessary information independently from the original sources.

The result has been that repeated and often burdensome requests for information by Government agencies have in turn generated complaints from business. Some restrictions to information exchange were of course created by legislative or administrative action to promote cooperation by private sources through guarantees of absolute confidentiality and anonymity of individual data, and through strict limitations on access and use of the data by Government officials.

But as illustrated above, one effect of the restriction is to increase the burden on the Government in seeking disclosure of corporate information. Even Congress is prevented by these restrictions from obtaining information necessary to its oversight and lawmaking functions. New legislation has recognized this problem, and the current trend is to allow agencies access on a discretionary, case-by-case basis through appropriate request to the holder of data,

At the incremental change level, the Materials Information Referral Office could have only a minor indirect impact, if any, on information exchange, since most current Government users of such information already know the location of the data sought. Likewise, the impact of the Coordinating Board, if any, could be minor and indirect. Use of materials information under existing conditions of interagency exchange could be aided by improvements in comparability and standardization of agency data bases.

Institutional arrangements at the intermediate change level could have a significant impact on the actual exchange of information between agencies to accommodate new Bureau operations. The Bureau would require the continuing cooperation of different agencies in the collection and submission of materials data for use in the summary data base and as input to the referral and statistical capability, Some discretionary revision of existing regulations and policies would be required. But, since both arrangements represent essentially statistical uses, the required information exchange could be accommodated under existing restrictive statutes.

Another minor but direct impact of a new Bureau is on laws restricting access to original data sources for validation purposes by personnel from outside agencies. Any conflict with existing law could be addressed in the enabling legislation for the Bureau. Alternatively, existing law could be interpreted as consistent with provisions of the Federal Records Act which, under certain conditions, expands access to include secondary users of restricted data as long as protection of the original data sources is maintained,

At the maximum change level. a new Administration could have impacts similar **to** those described for a new Bureau, with the additional possibility of minor institutional disruptions (since the Administration would have authority to determine the conditions of information exchanges and necessary changes in other agency data bases). Opportunities at this level are greater for direct conflict between enabling legislation and existing statutes which vest certain discretionary authority in collecting agencies. The Materials Statistics and Forecasting Administration has the additional dimension of access to forecasting and analytical information which in some sensitive areas, may meet with assertions of executive privilege and national security. Should such conflicts arise, their resolution may require court action or specific legislation and in the interim may cause minor disruption in some operations.

The Materials Information Commission could cause significant institutional disruption accompanying the likely modifications in Government materials data-collecting activities. Existing patterns and arrangements of materials data exchange could probably be replaced or revised. Comprehensive authority for data collection and validation would be placed in the Commission, with a reduction in the corresponding authority of other agencies. However, agencies would retain most responsibilities for actual collection of data, release of which to the Commission would be within relevant agency discretion, On the other hand, the Commission could exercise discretion over release of its own primary data to other agencies, Restrictions on disclosure of and access to Commission data thus could be a major and recurring issue.

3. Application of the Freedom of Information Act to Data in Materials Information Systems

The Freedom of Information Act **(5** U.S. C. **552)** affirms the right of any person to inspect and copy any Government information, documents, or record', with several snatnory exceptions, Data would, thus, be subject to the provisions of the Freedom of Information Act unless covered by a specific exemption, The major exemptions are those for privileged and confidential financial information submitted by a person, trade secrets, or other information exempted from disclosure under a specific statute, Current judicial trends have limited use of these exemptions. Confidential information is protected from disclosure only where disclosure would impair the Government's authority to obtain such information in the future or where disclosure of financial information would cause substantial harm to the respondent's competitive position,

Where a specific statutory exemption exists, even solely discretionary exemptions, the courts will generally uphold agency discretion. However, where only part of a document or record is protected, the exempt portion will be deleted and the remainder made public. Often, mere deletion of identifying information is sufficient protection for disclosure of remaining information which would otherwise be held confidential,

Under all arrangements with the increased availability of materials information, requests under the Freedom of Information Act can be expected to increase as discussed previously in the social impacts section,

Arrangements at the incremental and intermediate change levels (Referral Office, Coordinating Board, or new Bureau) could have no direct impact on freedom of information, Existing standards and exemptions could continue to apply with a policy in favor of disclosure, while at the same time maximizing protection of individual respondents. Some differences in disclosure decisions may be expected under the separate policies and statutes governing original collecting agencies. which may be resolved through agency action or legislation as needed.

In addition. specific statutory exemptions covering data could he enacted as part of authorizing legislation or appropriations acts. However, such special exemptions could limit access to data and may therefore be inconsistent with both freedom of information and the overall policy of open access.

Arrangements at the maximum change level (a new Administration or Commission) could have their own discretionary and statutory exempt ions, possibly placing 1imits on FOIA disclosure requirements. A desired major impact of all arrangements (except for the Referral Office) could he the necessary development (through legislation, regulation, and/or court action) of specific standards of confidential it y for sensitive materials information to the ultimate benefit of all parties.

4. Revision of Reporting Requirements for Materials-Related Industries

During the past seven decades, there has been increasing Government interaction with private enterprise in areas of corporate structure and finances, health, safety, labor relations, environment, energy, and raw materials, among others. The integrated capabilities could likely have some impact on Government involvement in the materials industry. At the least, a revision of and perhaps an increase in Government reporting requirements for data from materials corporations can be expected, This impact could range from minimal for the incremental change arrangements to perhaps quite substantial at the maximum change level. Government/industry interaction could also be expected to increase with respect to the administration and operation of materials information systems in general, the development of reporting mechanisms, and the setting of standards of confidentiality and public disclosure.

The improvements in knowledge of the materials industry may indirectly lead to other Government actions such as greater regulation of scarce materials, Federal incentives for development of critical resources, and changes in management policies of federally administered mineral and agricultural resources.

5. Promotion of Other National Policies and Programs

The energy crisis spurred investigations by various Federal agencies and congressional committees with respect to fuel resources and consumption. Results of these investigations showed lack of detailed, independent Government information on critical fuel materials.

The establishment of a materials monitoring apparatus may indirectly contribute to extending this national concern to other critical materials. The availability of comprehensive materials information to all branches of Government, business, and the general public could be expected to some extent to raise the level of consciousness of the general materials outlook. Should serious shortages be revealed, there could likely be greater pressure for corrective action under existing law and for new legislation. Arrangements at the incremental change level are least likely to have this kind of impact. While the likelihood is greater for arrangements at the intermediate and incremental change levels, in every case the impact will depend upon the extent of development and use of the integrated capabilities.

Another result may be to facilitate the application of existing laws which require advance consideration and planning of major Government and industry projects. Examples include the National Environmental Policy Act and land use planning statutes. Comprehensive data on national materials needs and resources could be used to make informed choices between competing values and interests, thus furthering the decisionmaking policies inherent in such legislation.

G. IMPACT OF ALTERNATIVE LEVELS OF IMPROVEMENT

1. Incremental Level

Arrangement 1 (Materials Information Referral Office) envisions the establishment of a materials referral service in a new or existing office of an existing materials-related executive agency. Through this service, users can locate existing information sources and data in that and other agencies and the private sector. No major impacts of this incremental level of improvement were found. There could be some added convenience for congressional staff; new users within agencies (who will not yet have made their own agency contacts); smaller U.S. firms; foreign industry and Government officials; public interest groups (or the general public) who have not yet developed expertise; and students, teachers, and researchers.

The Referral Office could tend to stimulate demands on existing information systems, and could marginally improve accessibility to such systems. Requests under the Freedom of Information Act can be expected to increase. Dollar costs could be relatively low, but the parent agency could require new positions and funds and could experience some incremental increase in public visibility and constituency.

Arrangement 2 (Materials Information Coordinating Boards) adds to the above the authority to facilitate information exchange by assisting other Federal offices and agencies to improve their own data classification and storage, developing governmentwide goals for standardized and compatible information systems, and providing governmental assistance for related improvements in the private sector. This could add some small but perhaps significant benefits for users inside and outside Government, for example, assisting a Federal agency to further develop its materials-related data collection or assisting State agencies or private firms just developing such collections. Development of standardized and compatible systems could tend to stimulate computerized interconnection between Federal agencies.

Thus arrangements at the incremental change level could lead to a marginal improvement in support for governmental planning and priority selection, and could moderately strengthen the ability of Federal officials to cope with materials-related problems. These arrangements could aid in the interagency exchange of materials information, and could stimulate some possible revision in reporting requirements for data from the materials industry.

Improved information services, if used by the private sector, could make a small but significant contribution to industrial planning and clarification of substitution and R&D options. Parallel improvements in the congressional agencies (e.g., CBO, CRS, GAO) could upgrade the information support available to Congress for materials policymaking. Thus, overall, there could be benefits (as well as dollar costs) for both executive and legislative agencies, benefits for industry and possibly for universities and research organizations, and general public benefits from improved accessibility and quality of materials information.

2. Intermediate Level

Arrangement 3 (Bureau of Materials Statistics) calls for establishment of a materials information office within an existing agency, The office will have a “clearinghouse” function (to provide data collected and analyzed by other agencies directly to users) as well as the referral service, and a statistical capability with a summary data base, The office will have some authority to check and verify information provided by other agencies, as well as the responsibility for improvement of existing systems provided in arrangement z.

The statistical reports will supplement those already produced in several agencies, thus providing some additional benefits for Federal policy analysts and decisionmakers. By making such statistics generally available, it could provide larger benefits to the private sector, chiefly to smaller firms who do not presently support this activity on their own. The net effect may tend to offset the information disadvantages of small firms relative to larger corporations. Similar benefits could accrue to public interest groups, and the public at large might be assisted (through the intermediary activities of the media and educators) to a better understanding of materials-related problems and the rationale behind governmental policy and proposed actions. This assumes that the media and educators will tend to use such statistical reports in the same way cost-of-living and unemployment figures are now used.

Perhaps as important, the bureau could provide a focus for the organization and integration of existing Government materials information systems and could permit application of the materials cycle concept to support the policymaking process. The new bureau could represent a significant impact for the parent agency, in terms of increased responsibility, budget, and constituency. While other agencies will still retain existing responsibilities for data collection and dissemination, they may perceive the bureau as representing a potential loss of relative influence and public visibility.

Arrangement **4** (Bureau of Materials Statistics and Forecasting) adds to the above the responsibility and authority for producing forecasts of materials supply and demand, and further analytical support for planning and policy formulation. By allowing all agencies and also industry to check their own projections against—and mesh them with—the bureau's forecasts, substantial benefits could accrue, particularly in contingency planning for materials shortages where concerted actions in the public and private sectors will be advantageous. It should be noted, however, that consistency in forecasts can have in some situations the effects which antitrust legislation is designed to avoid, that is, noncompetitive or even collusive activity among business enterprises, An indirect, small but cumulative impact of the forecasting function could be to support and stimulate the present movement toward research on and discussion of alternative futures,

The addition of forecasting and analytical requirements could greatly increase potential benefits to governmental policy makers by providing more consistency in the assumptions used for long-range planning by various agencies and the legislative branch, and thereby potentially contribute to broader consensus on materials-related issues. These requirements could add significantly to the ability of Federal decisionmakers to understand and analyze materials problems. Federal decisionmakers may reap secondary benefits if the new requirements lead to more informed public participation which is less apt to be hostile to governmental objectives. On the other hand, more available information may contribute to public interventions through court suits and administrative proceedings. And local government officials are apt to treat national forecasts skeptically where such forecasts conflict with local perceptions or priorities,

For the private sector, the forecasts and analysis could aid in industrial planning, clarify materials substitution and R&D options, and could provide a broader basis for Government/industrial cooperation in materials policy development and implementation. However, the perception of increased governmental activity and involvement in materials supply/demand planning could in some industrial quarters raise fears of increased constraint. regulation, and loss of proprietary information. The latter concern may be accentuated by the possibility of computer interconnection between the summary data base and other executive and legislative agencies. Conflicts between the public demand for access to information and the demand for protection of confidential information on the part of industry could very likely arise. Development of specific standards of confidentiality y for sensitive materials information will likely be stimulated,

3. Maximum Level

Arrangement 5 calls for the establishment of a new executive agency (here called the Materials Statistics Administration). Arrangement 6 (Materials Statistics and Forecasting Administration) is similar, but adds forecasting and analysis to the clearinghouse/referral, statistical, and data processing and collection capabilities of arrangement 5. In addition, both arrangements provide for authority where necessary to verify data at the original source of collection.

A new agency obviously implies much greater costs in money and manpower than the incremental and intermediate levels of change. It also implies much higher visibility and probably much more responsibility and influence for materials information than would be the case for an office in an existing agency. And a new agency could exhibit a much stronger tendency to aggregate materials information and analysis. Establishing a new agency could create a new force in materials-related activities and may constitute a significant loss of influence, personnel, and constituency for existing agencies. Additional authority to determine procedures for collection and validation of materials data might lead to new demands and checks on other agencies.

Conflict between public requests for information, under the Freedom of Information Act, and industry demands for protection of sensitive and confidential information could become more important with a new agency. The agency's independent collection and validation authority will require appropriate safeguards for protection of data prior to its aggregation into a summary data base.

At the level of visibility, activity, and influence associated with a new agency, the production of forecasts and analysis could serve to alert the private sector to impending policy developments and constraints—including possibilities for regulation or for subsidy where such are needed-early enough for industry to respond on a timely basis. An important impact at this level could be a strong stimulation for long-range and contingency planning and priority selection in both the public and private sectors, This in turn is likely to arouse controversy over the role of the Government in economic and social planning, Nonetheless, the establishment of a new agency could likely contribute to industry's capability to meet national material needs through improved business planning and clarification of substitution and R&D options,

The high level of analytical support capability and the provision of the summary data bank could provide major benefits to policy makers in a wide range of areas, from stockpiling and materials conservation to international trade negotiations and national security affairs, In all of these areas, however, information (and forecasts of supply and demand) is only one of many variables; therefore the impacts, while often significant, are in most cases cumulative over time and must be kept in perspective. For example, benefits to State and local decisionmakers may be outweighed by distrust or resentment of Federal involvement, resistance to growth in the Federal bureaucracy, and possibly from disruption of established contacts in the existing Federal agencies.

Arrangement 7 (Materials Information Commission) differs from other arrangements at the maximum change level primarily in two ways: it proposes that the new agency be an independent agency rather than an executive agency, and it also proposes additional authority for collection of data as needed for the development of a detailed data base, in some cases superseding the activities of existing agencies, It should again be noted that in all other arrangements, data collection (as opposed to accessing, categorizing, classifying, disseminating, and in some cases analyzing) remains the responsibility of existing agencies and falls under the existing safeguards and restrictions imposed by their enabling legislation, A commission would likely be more independent than the other arrangements but would have at least three possible disadvantages. Oversight by OMB might be avoided, and oversight by congressional committees might be reduced. Also a commission might be somewhat out of the mainstream of policy-making activity, and its activities could therefore tend to be duplicated within executive branch agencies. Finally, significant institutional disruption is possible since existing patterns of data exchange and reporting requirements and procedures will be subject to major revision.

H. OVERALL SUMMARY OF IMPACTS

This overall summary suggests which potential impacts of the institutional arrangements are likely to be most important to society, and whether these impacts are likely to be beneficial, mixed, or detrimental. Thus, the summary reflects both the magnitude and direction of impacts.

The first dimension, magnitude, is an analytical judgment based on the detailed impacts of identification and analysis of earlier sections. On the other hand, the direction of impact, while also based on the specifics of the analysis, is essentially a value judgment when viewed from the perspective of society as a whole. In the U.S. political system. the Congress and the President, as representative of the people, are the ultimate arbiters of social value, and have the responsibility to reach an overall judgment of social benefit and cost of the arrangements,

1. Impacts Judged To Be Beneficial

The most important beneficial impacts are manifested at or above the intermediate level of improvement and change represented by the Bureau of Materials Statistics and Forecasting. These impacts include:

- General strengthening of the Federal Government's capability to forecast shortages and crises, make contingency plans, and thus better understand and deal with materials-related problems;
- Substantially improve integration and organization of existing Federal Government materials information systems so as to provide better support for materials policymaking:
- Contribution toward a growing capability and tendency for identification of objectives and priority selection in the materials-related policymaking functions in both Government and the private sector; and
- Contribution to the capability of the industrial sector for short- and long-range corporate planning, including clarification of materials substitution and R&D options, as a basis for meshing corporate plans with the needs of society as perceived by Federal policy makers and for generally strengthening private sector capability to meet national materials needs.

Additional cumulative and important impacts (also judged to be beneficial) include:

- Reduction in the information disadvantage of smaller firms relative to larger firms;
- Increased public access to information;
- Increased public understanding of materials-related problems through the media and educational institutions:
- Improvements in materials-related public affairs programming and curriculum development through application of the materials life-cycle concept; and
- Opportunities for both intergovernmental (Federal-State-local) and international cooperation in materials problemsolving.

2. Impacts Judged To Be Mixed

Certain potential impacts must be viewed as beneficial or detrimental in relation to an observer's values. Many of the potential impacts point toward an overall stimulation of planning processes in the mixed U.S. economy, with a higher degree of cooperation between Government and industry, particularly large corporations, Another possible impact is increased opportunity for monitoring the materials-related activities of both business and Government. Similarly, some will welcome and others will view with alarm the likelihood that more fully integrated materials information systems will lead to greater use of computer-based analysis in support of materials policymaking. Finally, despite the clear benefits to private as well as public sector materials decisionmaking, some will distrust or perhaps even resent an increased role-even if only informational—for the Federal Government and bureaucracy in the materials area.

3. Impacts Judged To Be Detrimental

Important potential detrimental impacts, manifested most significantly at the maximum level of improvement and change (a new Administration or Commission) include:

- Potential, which with appropriate safeguards is probably controllable, for accidental disclosure or deliberate misuse or abuse of sensitive information, thus damaging the competitive position of some firms;
- Disbenefit to those who have profited (economically or politically) by control over limited information or to agencies whose constituency, funding, or mandate may suffer disturbance by creation of a new office or agency; and
- Increased direct dollar costs of materials information systems integration or improvement.

The first detrimental impact—the potential for harmful and unwarranted disclosure of private information—apparently could be avoided at the intermediate level of improvement and change, and at least moderated or controlled at the maximum change level. Most of the data supplied by individual companies would be legitimately considered confidential under the Freedom of Information Act, and additional protection from harmful public disclosure of sensitive corporate information is found in many other existing statutes and regulations, At the maximum change level (a new Administration or Commission), there is greater potential for data security problems associated with extensive use of computer data bases and interconnections. Thus additional legal, technical, and administrative safeguards may be needed.

The second impact—a disbenefit to those who profit by control over limited information or to other agencies whose constituency, funding, or mandate may be disturbed—is a potential public benefit or is neutralized in the long run. Disbenefits to particular groups or agencies must be weighed against the public benefits of an improved informational basis for public policymaking and better integration and organization of existing Federal Government materials information systems, among the other beneficial impacts discussed earlier

4. Conclusions Regarding Possible Impacts

The impact analysis suggests the following conclusions:

- The potential impacts of improvement in organization and integration of materials information systems in the Federal Government appear to be primarily beneficial. Moreover, the likely detrimental impacts in large measure are avoidable (through use of appropriate safeguards), controllable (within tolerable limits), or justifiable in the public interest.
- At the incremental level of improvement and change (establishment of a Materials Information Referral Office and improvement of existing data bases and systems through actions of a Materials Information Coordinating Board), all impacts could be minimal or marginal. Benefits do

not appear to be of major or overriding significance, and costs appear to be negligible.

At the intermediate level of improvement and change (establishment of an Office or Bureau of Materials Statistics and Forecasting, or the equivalent), many impacts could become significant. At this level and above, some of the potential impacts appear to be critical or of overriding importance relative to other trends in society, the Government, and the economy. And even those impacts which in the short-run are marginal or minimal may assume cumulative importance over time. Overall, potential benefits of a Bureau of Materials Statistics and Forecasting (or the equivalent) are judged to substantially outweigh any potential detrimental impacts,

- At the maximum level of improvement and change (elevation of the materials information office or bureau to agency status in the form of an Administration or Commission), several impacts could be very beneficial, However, at this level the possible detrimental impacts or costs could be significant enough to warrant very careful consideration of the trade-offs involved,

Chapter VIII

IDENTIFICATION AND ANALYSIS OF PUBLIC POLICY ISSUES ‘

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IDENTIFICATION AND ANALYSIS OF PUBLIC POLICY ISSUES

Consideration of the materials information systems alternatives highlight a number of interrelated public policy issues. In this study, materials policymaking is viewed as the definition, by high levels of Government and other social institutions, of an overall plan incorporating goals and suggesting the general sense of direction or development in materials-related areas.

Based on the impact analysis, the public policy issues likely to arise in the planning, or operation of one or more of the institutional arrangements are identified in this chapter.

A. INTRODUCTION

In this assessment, the public policy objective implicit in the seven institutional arrangements is to meet the policy-level materials information needs through one or more of a series of progressively stronger legislative/executive actions to integrate and upgrade the existing Federal Government materials information systems.

As the impact identification and analysis make clear, the number and intensity of impacts increase as the level of improvement and change moves from incremental to intermediate to maximum. The possibility that these impacts will generate conflict among stakeholders increases in a similar fashion.

For the most part, the issues discussion is oriented toward the broad social, economic, political, and legal context rather than to specific arrangements. Based on the impact analysis, the public policy issues likely to arise in the planning or operation of one or more of the institutional arrangements are listed below in order of relative importance:

- Role of the Federal Government with respect to private sector materials information;
  - Authority of the Federal Government to require disclosure of materials information by business enterprises;
  - Openness in Government, and the protection of confidential business information; and
  - Distribution and control of (and access to) materials information in society.
- Competition within the American economy;
- Growth of governmental planning;
- Future of intergovernmental (Federal-State-local) relations; and
- Participant on in the American poltical process,

B. ROLE OF THE FEDERAL GOVERNMENT WITH RESPECT TO PRIVATE SECTOR MATERIALS INFORMATION

Since much of the information necessary for public policymaking in the materials area comes from private sector data, an immediate issue to consider is whether the Federal Government has a proper role with respect to such data. Or, as some question, is expanded Federal concern over private sector information an unwarranted extension of governmental involvement which runs the risk of unfairly compromising proprietary information and the competitive positions of private enterprise. This issue area is addressed in this section from the viewpoint of political economy, and then in the following two sections from a legal perspective. There are at least two basic issues emerging with respect to the role of the Federal Government in meeting these needs as they relate to the private sector.

First, to what extent should the Federal Government provide further support for improvement and development of private sector materials information? The Federal Government already plays a role here, but the results of this assessment suggest that a more intensive level of support may be needed. Much of the information needed for private sector decisions on materials R&D and engineering design (e.g., information on mechanical, chemical, and physical properties, fabricability, toxicity, and corrosion resistance) is not of direct relevance to Government policy makers. But this kind of information is essential to efficient and effective private sector allocation and use of resources within the broad framework of materials policy. To the extent that realization of public policy depends on private sector activities, it may be argued that it is in the public interest for the Federal Government to provide further support for improving sectoral materials information, even though such information is primarily used by and remains in the private sector.

Second, to what extent does the Federal Government need additional materials data from the private sector? As discussed earlier, the Federal Government already collects a broad range of materials data from the private sector, The results of this assessment suggest that, while new data will be needed (e.g., data on energy use, transportation, and life-cycle costs), the Government's materials information problem is primarily one of inadequate information management, ineffective systems integration, and insufficient analysis rather than incomplete data.

Only a small fraction of private sector data is really necessary to Government policymaking. More information does not mean better information. In order to avoid placing unnecessary reporting burdens on the private sector, and to prevent further information overload of Government policy makers, a priority-setting process is needed to help identify exactly which additional data are needed,

Given improved materials information management and analysis in the Federal Government, a case for limited Government collection of private sector data can be made along the following lines. First, private sector decisionmakers themselves need information (e.g., supply and demand statistics for critical commodities) which, for competitive, cost, and antitrust reasons, among others, can realistically be collected and aggregated only by the Federal Government. Second, because the private sector accounts for the vast majority of materials-related economic activities both at home and abroad, information about such activities is essential to U.S. Government policymaking, Third, private sector materials-related activities have direct and indirect effects (benefits and costs, internal and external) on many other sectors of society. The Government may be regarded as having a legitimate need for information necessary to help ensure that the net effects of private sector actions are consistent with public priorities. The constitutional and legal bases for Government involvement are discussed in subsequent sections.

The following sections discuss in detail the legal, administrative, and judicial precedents for safeguarding against harmful and unwarranted disclosure of private sector information in ways which are consistent with public policymaking needs and the open access precedents of the Federal Government.

C. AUTHORITY OF THE FEDERAL GOVERNMENT TO REQUIRE DISCLOSURE OF MATERIALS INFORMATION

1. Sources of Federal Jurisdiction

The Federal Government derives its fundamental authority over business activities from the Constitutional grants of power to the Congress to regulate interstate and foreign commerce, to provide for the national defense, and to regulate the disposition of property belonging to the United States.

One principal purpose of establishing more comprehensive and integrated materials information capabilities is to provide Government agencies with timely, accurate, and credible materials information for informed decisionmaking. The integrated capabilities are therefore a continuation of existing Government policy. The arrangements rely primarily on existing Federal authority to gather materials data from broad segments of the economy. Only in institutional arrangement 7 (the Materials Information Commission) is there an apparent increase in Federal power achieved through the reordering of existing patterns of authority. The Federal Government has extensive investigatory powers which enable it, through various agencies, to inventory and monitor all phases of materials production and consumption.

2. Limitations on Exercise of Federal Authority

In evaluating the validity of assertions of corporate secrecy in the face of Government requests for disclosure, two facts should be remembered; first, corporations are creations of law; and second, corporations do not possess the same Constitutional protections of the Fourth and Fifth Amendments as individuals.

Because corporations are creations of law, the Government may impose conditions on their creation, including conditions relating to provision of corporate information to the Government.

Corporations are protected against unreasonable searches and seizures under the Fourth Amendment, but the standards are broader than those for individuals. Under current law, courts will issue subpoenas for corporate records if (a) the request is within the authority of the agency; (b) the demand is not too indefinite; and (c) the information is reasonably relevant to the inquiry. United States v. Morton Salt Co., 338 U.S. 632 (1950).

The Fifth Amendment privilege against self-incrimination does not apply to corporate books and records. The Supreme Court held in Hale v. Henkel, 201 U.S. 43 (1906), that corporations were not "persons" for the purposes of self-incrimination under the Fifth Amendment. Thus, disclosure is required even where the information would reveal criminal activity by the corporation or its officers or employees. When an agency or official which is vested with jurisdiction over matters relating to materials resources and investigatory powers issues a lawful request in accordance with relevant procedures and regulations for the disclosure of corporate information, the request will be enforced over any assertions of corporate secrecy.

3. Conclusion

Proposals for establishing comprehensive materials information capabilities utilizing modern information management techniques have been criticized by both industry and Government as Federal intrusion into private corporate affairs, An examination of the sources of Federal authority to gather materials information, the limits on its exercise, and their applicability indicates that establishing such integrated capabilities would (a) be consistent with existing recognized Federal regulatory powers, (b) not greatly expand, if at all, Federal authority over the materials industry, and (c) not violate any recognized rights of "corporate privacy, " given appropriate use of checks and balances as discussed later.

D. OPENNESS IN GOVERNMENT AND THE PROTECTION OF CONFIDENTIAL BUSINESS INFORMATION

A major consideration should be the treatment of sensitive data supplied by business sources. This issue reflects the fundamental differences of values reflected in demands for open, public access to information in the possession of the Government, and assertions of corporate privacy for the protection of competitive economic advantages. Balancing these conflicting interests, while at the same time advancing system goals, will be a substantial challenge. To that end, the principal laws governing public access to Government information and restrictions on use of confidential information are summarized and compared with some categories of information to be included within the integrated capabilities.

1. Public Access to Information

Public access to materials information and participation in the formulation of policies are guaranteed under the Administrative Procedure Act, 5 U.S. C. 551 et seq., the Freedom of Information Act, 5 U.S. C. 552, and the Federal Advisory Committee Act, P.L, 92-463, 88 Stat. 770. The chief basis for public access is the Freedom of Information Act (FOIA) which provides that any person, including a corporation, has a right of access to any document, file or other record, including computerized records, in the possession of any Federal agency or department unless such material is subject to one of nine specific statutory exemptions. Another factor favoring public access is that many agencies have as part of their responsibilities, the collection and publication of materials commodities and resources information and statistics for public use. (See Joint Hearings ***on the*** Domestic Supply Information Act before the Senate Committee on Commerce and Senate Committee on Government Operations, 93d Cong., 2d Sess,, at 149-154 (1974).) The principal agencies exercising such authority are the Departments of Commerce, Agriculture, and Interior, and the Federal Energy Administration. The Securities and Exchange Commission also maintains public information on the structure, financial condition, and activities of many corporations in the materials industry. In recognition of the importance of such information to public and private decision making, large quantities of materials information are already made public under existing policies and programs,

2. Protection of Confidential Business Information

The Freedom of Information Act, 5 U.S.C. **552 (b),** includes nine categories of information which are exempt from the compulsory disclosure provisions of the Act. Of particular relevance to materials information systems are two exemptions:

(a) Matters specifically exempted by statute, 5 U.S.C. **552 (b) (3).** This exemption is intended to preserve the protections of confidentiality afforded under almost 100 other statutory provisions. For a partial list of these statutes, see Federal Statutes on the Availability of Information, Committee Print, House Committee on Government Operations, 86th Cong., 2d Sess. (1960).

(b) Trade secrets and commercial or financial information obtained from a person and privileged or confidential, 5 U.S. C. **552(b) (4).** To invoke coverage of this exemption, the information must be a trade secret under the strict meaning of the term or be commercial or financial information obtained from a person (including a corporation) and privileged or confidential. Trade secret is construed to mean an unpatented. secret, commercially valuable plan, appliance, formula, or process, which is used for the making, preparing, compounding, treating, or processing of articles or materials which are trade commodities. United States ex rel. Norwegian Nitrogen Products v. United States T'ariff Commission. **6** F. 2d 491, 495 (D. C. Cir. 1925), rev'd on other grounds, **274** U.S. 106 (1927). Privileged information includes matters covered by traditionally recognized privileges such as the lawyer-client privilege. Commercial or financial information is exempt from disclosure, if privileged, or if within the standard of confidentiality set forth in National Parks and Conservation Association v. Morton, **498** F. 2d **765, 770** (D.C. Cir. 1974). Information is confidential under this exemption if disclosure of the information is likely to impair the Government's ability to obtain necessary information in the future or to cause substantial harm to the competitive position of the person from whom the information is obtained. Where the Government possesses mandatory authority to obtain the necessary information, the first test in National Parks is inapplicable since no impairment of its collection power could occur. This standard places the burden upon the Government and the source to show a likelihood of substantial harm to competitive position from disclosure, severely limiting the effectiveness of agency practices which conferred blanket confidentiality to information supplied by private sources, in the absence of a specific statutory provision, (See Case note, 88 Harv. L. Rev. 470 (1974),)

A significant limitation on the use of these exemptions is the provision that reasonably segregable portions of requested documents must be disclosed after deletion of exempt materials. Often the deletion of identifying materials is sufficient to justify the release of some confidential information. Finally, it should be remembered that the Freedom of Information Act exemptions do not forbid disclosure; they are discretionary, Documents and records may be released to the public even though covered by one or more exemptions where such release would not constitute an abuse of discretion or violate other statutory prohibitions.

18 U.S.C. 1905 imposes criminal penalties for the unauthorized disclosure of trade secrets and confidential information by Federal officials and employees. This statute covers information relating to "trade secrets, processes, operations, style of work, or apparatus or to the identity, confidential statistical data, amount or source of any income, profits, losses, or expenditures of any person, firm, partnership, corporation, or association, " Section **1905** is frequently referred to in other statutes for its definition of trade secrets and confidential information. The section does not create further exemptions to the Freedom of Information Act, but merely punished the unauthorized disclosure of such information whether exempt or nonexempt under FOIA. Section 1905 has been the basis for several "reverse freedom of information suits" in which corporations attempt to enjoin agency release of documents concerning them pursuant to a FOIA request, The corporate plaintiffs have asserted that release of information which is exempt under FOIA and which is

described in section 1905 violates the criminal prohibitions of section 1905 and, therefore, constitutes an abuse of discretion reviewable under the Administrative Procedure Act, 5 U.S.C. 701-06. Charles River Park "A", Inc. v. Department of H. U. D., 519 F. 2d 935 (D.C. Cir. 1975); Sears, Roebuck and Co. v. General Services Admin., 509 F. 2d 527 (D. C. Cir. 1974). Some legal authorities have advanced the theory, as yet untested, that these cases recognized, at least tacitly, the right of a corporation to sue to prevent substantial harm to its competitive position from unauthorized disclosure of confidential information and might serve as precedent for a suit against the Government and/or an official or employee disclosing such information for any resulting damages.

In addition to the criminal sanctions of section 1905, many statutes dealing with specific commodities or agencies contain criminal penalties for unauthorized disclosure of protected information. Moreover, the Federal Reports Act, 44 U.S. C. 3501 et seq., contains a provision which sets forth conditions under which confidential information obtained by one Federal agency may be released to other Federal agencies and extends the application of any legal restriction on the use of such information by the first agency, including penalties for unlawful disclosure, to the officers and employees of the second agency. The Federal Reports Act in combination with specific statutory grants of confidentiality preserves the confidential classification of information obtained from private sources.

A major concern of Government and materials industries representatives interviewed in connection with this assessment was that broad public access to the system would result in the unwarranted disclosure of corporate "proprietary information. " Proprietary information is not synonymous with confidential information, privileged information, or trade secrets, as previously defined, nor is it, in itself, a category of protected business informat ion, While assertions of corporate secrecy and privacy are an insufficient basis to refuse disclosure of corporate information to Government agencies, some recognition is granted to the needs of business entities to prevent certain sensitive information from being revealed to their competitors and the public, Government agencies recognize this legitimate concern and carefully protect such sensitive matters to preserve their good relationships with their information sources, Corporate "proprietary" information is protected from public disclosure to the extent that it comes under one or more specific statutory provis ions,

3. Conclusions

Most of the data supplied by individual companies would be legitimately considered confidential under the Freedom of Information Act, and additional protection from harmful public disclosure of sensitive corporate information is found in many other statutes and regulations. The design of a statistical information system also offers protection to individual company data. The system is primarily concerned with statistical trends and would use information aggregated from individual reports. Anonymity of individual data sources could be maintained with the use of special identifying codes and internal system security which would limit access to individual reports and reduce possibilities of accidental disclosure. It is probable that the system would utilize statistical sampling methods and would survey only a small number of firms in each of the many sectors of the materials industry. This approach would not result in the accumulation of massive files on each company in the materials industry. Acceptance of the system would be promoted by advance determination through regulatory or legislative action of the standards for classification of confidential information and for the availability of individual company reports for inspection by other Government agencies. The interaction of the system with existing Government policies on openness and confidentiality would result in a materials information system which offers comprehensive and accurate materials information to Government and public users and which utilizes and protects sensitive corporate information.

E. DISTRIBUTION AND CONTROL OF MATERIALS INFORMATION IN SOCIETY

American society faces a difficult dilemma when it comes to the distribution and control of information in important areas 1ike materials. On the one hand, conditions of information overload and complexity are such as to require better management control over information, for which computers and other information technology are some of the most useful tools available. Yet at the same time, there is great concern over possible threats to privacy and excessive concentrations of information which are made possible through data banks and interconnected computer systems. In this respect, concern has been expressed that the institutional arrangements will lead to excessive centralized control over materials information,

Protections against abuse have been built into the arrangements in the following ways. First, arrangements like a super-statistical agency (which would centralize in one institution all materials information activities of the Federal Government) have been ruled out, This kind of arrangement appears to constitute a clearly excessive concentration of control (and power), is contrary to many existing statutes, and represents a potential administrative nightmare. Second, the legislative mandate and anticipated budget restrictions for each arrangement are intended to limit the scope of activities to priority information needs.

This limitation is founded on the premise that, while information is essential to materials policymaking, too much information can be just as harmful as too little. However, as the various sectors of society become more interdependent and tightly linked, as is the case with regard to materials, information on external factors and interactions becomes more important. Some degree of centralization is required to provide such information. Essentially, the purpose of the integrated capabilities, when viewed in these terms, is to provide the degree of centralization (through integration and upgrading of Federal Government information systems) necessary for provision of adequate information on the aggregate interactions and interfaces between the major social entities in the materials-related sectors of society. The capabilities are not primarily concerned with the internal workings of specific institutions (e.g., specific corporations), except to the extent validation of internal data is necessary to ensure reliable summarized and aggregated data.

Third, each arrangement is subject to a number of checks and balances, in addition to the necessary technical security measures: (a) the basic grant of authority which requires that Congress, the President, and the public have access to all policy-relevant information, subject to protections of data sources and proprietary information; (b) the application of existing statutes (e.g., the Freedom of Information Act, Privacy Act, Administrative Procedures Act, and Federal Reports Act); (c) the direct monitoring of activities by both OMB (for the President) and GAO (for the Congress); (d) periodic oversight by relevant congressional committees; (e) the authorities of existing agencies which by and large protect business firms from disclosure of sensitive information; (f) the necessary cooperation of existing agencies for actual collection of materials data and cooperation of the business community in provision of such data; and (g) the exclusion of any substantive policy or regulatory responsibilities other than those relating directly to materials information.

The intent of these checks and balances is to help ensure that the arrangements can achieve their primary objective of providing materials policy makers with aggregated materials information from a centralized location, but without permitting excessive centralized control over (or potential abuse of) such information or the detailed data on which it is based, Overall, the arrangements are intended to augment and build on, but not supplant, the essentially decentralized systems now operative,

F. COMPETITION WITHIN THE AMERICAN ECONOMY

In view of the fact that information and knowledge are keys to the competitive position of most American businesses, concern has been expressed as to how competition among profit-minded organizations in the United States can be influenced. Government's traditional role in America has not been to control, but rather to promote competition in most areas of the economy-except in certain cases, such as public utilities, where competition has been deemed undesirable, When construed as essentially a governmental intervention into the economy in the areas of materials, how will the dynamics of the economic system be affected? Will they tend to undermine or strengthen current patterns of competition?

1. Materials Substitution

From the standpoint of producers who accept the reliability of data and use it, an improvement in the information flow will provide new and timely knowledge concerning alternative sources of materials supplies, and will allow businesses to better select from among various substitution options, These developments will obviously affect competition. The competitive edge of some companies will be enhanced, since new data would lead, for instance, to innovative combinations of materials for more efficient production processes, more effective allocation of scarce resources, and improved product lines.

Through the use of improved data, the realization of production alternatives will improve or change the life and type of products, and therefore will alter present patterns of competition. If new products last longer and are more useful, the quality of competition is enhanced in that other resources are conserved. Producers will experience and adjust to new dynamics in product turnover and variety as a result of the continuing utilization of data. In competing for a specified market which is sensitive to product quality and type, producers will be continually concerned with improving or altering the type and life of products so as to appeal to consumers, better use of scarce resources, and thereby increase profits,

2. Materials Research and Development

Another topic which deserves attention involves the relationship between the institutional arrangement and private research and development. Traditionally, materials information resulting from R&D has contributed to new products, many made with substitutes and synthetics, Data will to varying degrees influence this private R&D, thus affecting competition, Some R&D activities will undoubtedly be expanded in areas which in the past have consumed scarce resources, because data will suggest where the greatest savings and profits may be made, In other areas, R&D may be reduced or eliminated due to market rejection of a specific product which must rely upon key materials in short supply.

Due to shortages, industrial R&D may focus on possible technological innovations which would increase the efficiency of recycling and waste reduction, or allow greater use of abundant resources which may be substituted for more scarce ones. In other areas, for example copper, R&D addressing new mining technologies could contribute to lower costs, and to controlling pollution and land use problems associated with production and solid waste disposal. It may be possible to promote more R&D cooperation between some companies, particularly where the return has been low in the past. In other areas, R&D competition may increase because of high returns. providing companies with the knowledge of where investment should be made and where profits are likely to be greatest.

3. Industrial and Business Planning

With implementation of the integrated capabilities, companies will have an increased opportunity to improve their planning processes and activities, which are often closely associated with research and development. Improved capabilities would help in shifting the content and perception of developing industrial plans. In the past. information about a specific resource or material has generally been quite limited at a given point in time; plans have been formulated on the best available data, with resources allocated accordingly. Improved knowledge concerning a particular trend in materials allocation, location, and rate of depletion should enable the relevant policy makers to reduce potential costs and risks while planning new and better lines of products,

Where reasonable profits can be made through production of these new products, corporate policy makers may increase the availability of resources by turning more to conservation or rationing activities, which will assure supplies for a longer period of time. Since more comprehensive, reliable, and timely information about materials will be available from the materials information systems, planning and related managerial functions will play a large role in increasing the likelihood of survival of a specific business enterprise, given the forces of a competitive market. Increasing the efficiency of production activities will result in better use of resources and reducing the relative costs of production, thereby improving the quality—if not the quantity-of competition,

4. Competition Among Smaller Versus Larger Firms

As a consequence of the growth of alternative sources and substitutes of materials, and changes in R&D and planning activities, the question arises as to a change in relative market competition among smaller and larger firms. It is difficult in many instances to determine with certainty whether competition here will increase or decrease. It is not clear, for example, how the large volume and improved quality of data would help small businesses. since they do not deeply engage in long-range planning. By contrast, this data would be of value to larger firms. Yet the smaller businesses may also benefit from the data, since they now tend to be at a distinct information disadvantage,

Many smaller firms usually do not have adequate analytic capabilities even to handle the data already available, So more and better data alone are not likely to make much difference. However, if small firms are offered data as well as analysis, an improvement in their competitive position relative to larger firms could be stimulated, Even so, it seems clear that information per se (whether data, statistics, forecasts, and/or analysis) will not in any case lead to a revolutionary competitive realinement for small business.

5. Role of the Federal Government

The competitiveness of the American economy may also be affected by changes in the policies of the Federal Government. The role of Government policy is in part to ensure adequate materials supply and reserves, while simultaneously meeting other goals such as maintaining environmental quality. Integrated capabilities could stimulate consideration of changes in governmental regulatory activities—toward greater intervention into the economy, or toward deregulation,

Government's need to affect economic activities, in view of the materials situation, may induce changes in trade legislation, corporate antitrust laws, standards for product performance, or requirements concerning environmental quality. In addition, there could develop changes in the U.S. tax system toward domestic and foreign operations, such as to increase or decrease import/export restrictions, Other governmental actions, such as new taxes or subsidies, could be taken to encourage industry to cooperate with national goals concerning recycling and reuse. Based on improved data, the Government might also encourage life-cycle cost accounting, so that the final cost of a product will more closely reflect the total social costs of producing it. The Federal Government, as the largest single consumer, will also tend to influence market changes through its own buying activities, which may for example alter competition for various governmental contracts.

6. Conclusion

In conclusion, the functioning of the economy and the society upon which it depends should be improved. Both producers and consumers will be subjected to the reality of the general materials situation in this country and to detailed knowledge about it. One is complementary to the other, They may be two different segments in the market structure, but they are both part of the same market environment,

G. THE GROWTH OF GOVERNMENTAL PLANNING

An important political issue involves the way in which integrated materials information capabilities are likely to relate to local, State, and national governmental planning in the United States. The institutional arrangements do not make plans themselves. Their mandate specifically excludes any planning or policymaking responsibilities. except for plans and policy on materials information. However, the arrangements are designed to support planning and policymaking processes in other agencies of the Government.

1. Public Planning in the United States

Public planning in the United States has always reflected the major traits of the American political process at any particular point in its evolution. Because power is dispersed throughout the political system, no one power center exists for planning without a complex system of checks and balances and separation of powers to guard against abuses in decision making and to protect the legitimate interests of all major sectors within society. The United States thus does not maintain a formal, highly structured planning process. Plans evolve in large part through the normal workings of the political process, with multiple actors and power dispersed throughout the private and public sectors.

Poor planning may be worse than no planning. In order to plan effectively and efficiently in the area of materials and resources, decisionmakers need the most timely, comprehensive, and reliable information available. Better information does not necessarily mean improved planning, but it does usually tend to affect the planning process, especially if it is available in an accurate, useful, condensed form which will facilitate decisionmaking, Decisionmakers must avoid information overload, even in an area as critical as materials shortages. More importantly, key decisionmakers need high-level forecasting and analysis which will help their decisions address the true complexities and interrelationships which must be considered.

2. Materials Planning at the Federal Level

The executive branch has been unable to plan effectively for real and potential materials shortages because of inadequate organization, conflicting or uncoordinated data, and insufficient analytical resources. Overlapping policy functions exist throughout the executive branch, leading to fragmented policymaking in many instances. Moreover, the Federal decision making process is crisis-oriented and, many concerned interest groups—both consumers and producers—have limited inputs. Although some steps have been taken during the 1970's to improve materials policymaking and planning resources at the national level, they nevertheless continue to be generally inadequate for coping with present and future problems.

To varying degrees, each of the seven institutional arrangements would potentially help in overcoming some of these Federal-level materials planning problems, by reducing fragmentation and overlapping in materials data responsibilities shared by various Federal agencies. This should make for more informed and timely short-run materials decisionmaking at all levels of Government. In some areas where long-range Federal planning is particularly needed, such as in energy and mineral resources, it should also promote a continuous planning process as opposed to the ad hoc, crisis-oriented process which has historically been evident. Further, improved information would tend to generate additional change in the traditional institutional structure in materials planning since its existence would likely make executive and congressional leaders more aware of the need for less fragmental ion in responsibilities for meeting short-run and long-run problems.

Planning would also be facilitated under some alternatives by improving the ability of decisionmakers to map out policy options and priorities for a higher level of responsiveness to materials questions. And finally, group participation could be increased because of data collection, clearinghouse, and referral functions available; the resulting new inputs from these groups would strengthen the democratic aspect of Federal materials planning.

3. State/Local Materials Planning

While Federal materials planning could potentially be improved, the same is true, at least in part, at the State and local levels. For example, data and trend projections would be useful to local and State governments which are accelerating their land use planning activities. These activities are directly related to materials issues, as in the case of restrictions on new development (to preserve land for forests, agriculture, parks, etc.) affecting the building trades, projected highway systems, energy conservation, and so on. Moreover, land use management provides an excellent example of State and local planning which is (at least in theory) "comprehensive" in nature, affecting so many fundamental aspects of everyday life. In the past, many land management decisions, such as those relating to protection of agricultural lands, were based upon guesses and assumptions as to future materials supply and demand.

The same potential contributions are likely in State planning, where the "quiet revolution in land use control" has accelerated since the late 1960's. The States do not want to be told by the Federal Government how to plan the use of land. However, State governments do need data and projections concerning the interrelationships between land, environment, industrial and commercial expansion, and new residential development of large-scale proportions. More generally, they need a systematic means for inventorying, monitoring, and evaluating the desirability of particular types of land usage, and for judging the effectiveness of different growth management schemes. They now have information for these activities only in the primitive sense of dated highway and tax maps, limited field

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work, and aerial photography, Improved statistics and forecasting would be of value in supplementing these traditional sources of data for planning purposes.

H. THE FUTURE OF INTERGOVERNMENTAL RELATIONS

Representatives of State and local governments have expressed concern over the implications for intergovernmental relations, A key question is: What new developments would accompany the implementation of integrated materials information capabilities?

1. American Federalism and Materials Problems

Materials supply problems are frequently regional, national, or even international in nature, Although State and local action is essential to the implementation of materials programs, State and local officials have necessarily relied in large measure on the Federal Government for formulating these programs. Moreover, possible alternative solutions to materials problems may entail great expenses, and thus, for example, few States have found the funds for developing materials data base information systems for assisting in problemsolving, It follows that, for the most part, the States maintain a reactive rather than an active posture. They cannot initiate broad-ranging materials policies and generally cannot afford sophisticated information systems as one means of assisting in solving problems.

2. Intergovernmental Cooperation

intergovernmental cooperation might be improved where State and local governments are able to draw upon and use data in solving local and regional problems. Obviously, regional data would be valuable to these officials, Energy data would be useful for a wide range of State conservation programs, Integrated capabilities would assist in responding to the 1975 Governor's Conference proposal concerning the creation of an interstate energy clearinghouse. Similarly, the utility of integrated materials information capabilities was suggested in a tentative draft of the energy facilities siting resolution adopted at the Conference, stating that ". , . the Federal Government can take the lead in amassing the information on which every level of government and private actions can be most confidently based, The Federal Government should accumulate data from public and private sources and establish a framework in which energy information is maintained accurately, completely, currently, and in uniform modes. " (National Governor's Conference Tentative Draft of Resolutions, New Orleans, June, 1975, page 16, mimeographed.)

Integrated capabilities could also positively affect the fact that different States may have opposing interests in certain materials areas, as in the case of States dependent on others for petroleum but still seeking the most reasonable prices possible, In such instances, through improved data, they may at least be able to appreciate more fully the perspectives, problems, and concerns of other States or different parts of the Nation.

All this is not to suggest, however, that a majority of State and local leaders will regularly utilize the integrated capabilities soon after implementation, They must clearly provide relatively reliable, timely, and comprehensive data. Having met this condition, if the institutional location is generally acceptable to them, and is largely a collection and clearinghouse facility, its usage by State and local officials should steadily increase over time. This would be a positive contribution to cooperative federalism.

3. Intergovernmental Friction

Just as greater intergovernmental cooperation may indirectly result from integrated capabilities, so too may many frictions develop among actors in the Federal system because of their existence. States with substantial resources might oppose any further Federal knowledge of, or certainly influence over the use of, their materials. From the State standpoint, materials development and conservation programs should not be required through Federal law. This could avoid providing a symbol for a States rights reaction. even if State fears as to Federal influence were unwarranted, which might trigger some greater degree of regionalism and interregional friction among the States, or influence States to adopt more narrow points of view with reference to their own resources.

These potential sources of intergovernmental conflict could likely lead to discontent if the collection and clearinghouse/referral functions are not separated from the analytic functions. A strong preference for such a separation surfaced during the 1975 Governor's Conference meeting, where the creation of ERDA was praised as a notable illustration of how regulatory functions should be separated from research, development t, and promotional capacities. State opposition to the analytic function essentially reflects the fear of another Federal materials agency ultimately possessing regulatory powers. States could also grow to question whether political pressure was being exerted on the process of designating "policy options. " If the above developments do not occur, however, State and local governments could be aided through a more centralized location from which they could request reliable and comprehensive materials data.

4. Conclusions

With regard to federa1ism, integrated capabilities will assist State and local governments in understanding and perhaps coping with their materials problems. They may still rely primarily on the National Government for financial and technical assistance, and for broad materials policy affecting resource development, distribution, and usage throughout the country, But valuable roles which State and local governments can play include policy implementation; providing data to Federal agencies. and identifying public needs as part of the national materials decisionmaking process. However, integrated capabilities can best contribute to a spirit of intergovernmental cooperation by providing materials data and clearinghouse/referra1 services, not high-level policy analysis which some State and local officials believe could lead to further regulatory powers located within Federal agencies.

I. PARTICIPATION IN THE POLITICAL PROCESS

A chief issue emerging from the question of creating and implementing the integrated capabilities concerns the ways in which they will relate to the democratic political process in the United States. This issue is analyzed here through the central organizing question: How will integrated capabilities contribute to more widespread political participation and influence by various interests in the public and private sectors?

1. Role ofInformation

Additional information per se will not ensure greater participation or influence by public or private groups in the political process. Information is, however, a political resource. It provides one basis from which groups may more effectively participate and exert influence-provided that they choose to use it and provided that they have access to key political actors.

Obviously, one step in the political participation process involves persons seeking and acquiring data from which they may express an informed view. Without timely and accurate information, participation is less meaningful and the ability to influence policy is undermined. As participation diminishes. so does the potential or actual power of that individual or group within the social fabric. It follows that reasonably widespread participation is a crucial underpinning for democratic government. By being able to participate in the political process, individuals and groups may consent to the policies which govern their lives, and by being able to bestow or withdraw their consent, they may ultimately hold government more accountable.

2. Reduced Barriers to Participation

In varying degree, a particular alternative would contribute to removing some of these barriers to wider political participation in materials policy formulation. Theoretically, group participation could increase, remain roughly the same as it has been in the past, or decrease, But most changes are likely to be in the direction of increased participation. Many interest groups and governmental officials in the public sector do not have ready access to important data on materials, and they will thus tend to benefit from integrated materials information capabilities.

Each of the seven institutional arrangements will tend to facilitate increased participation by those individuals and groups which previously have lacked access to public data because of its cost, the lack of knowledge of how to acquire the data, or a number of other practical reasons. The alternatives, by contrast, are unlikely to reduce access and current levels of participation by groups in the public or private sectors, although there may be shifts in the degree of influence exerted by these individuals or groups on policy formulation.

On balance, integrated capabilities could provide the basis for higher levels of participation by all public or private groups, more informed and valid criticisms of specific materials policies, and ultimately a more responsive political system. When materials problems occur to the extent that the general public must change its basic lifestyle, or to the point where profit-making companies lose money, pressure could be exerted more readily on political decisionmakers who had ineffectively used— or failed to take into account-data to anticipate and cope with those problems. Such participation and influence could ultimately contribute to a political system more accountable to all groups.

3. Wider Range of Participation

In terms of the Government, Federal executive and legislative agencies will participate to a greater extent in the sense of engaging in additional data collection, clearinghouse, and analysis activities. These activities will make new data inputs available to the political process. Participation, in the form of added inputs from existing Federal agencies, should provide decisionmakers in the public sector with data and forecasts previously unavailable or difficult to acquire. In particular, this would mean more informed participation in materials policymaking by elected and appointed officials at all levels of government, if they are aware of and use the services provided. Although their materials problems tend to be local or regional in nature, State and local officials throughout the Nation would also have a timely source of information with which to anticipate future developments and to gain an overview of related problems in adjacent areas.

Political participation by public interest, environmental, and trade association groups will increase since many of the additional services provided by Federal agencies will be available to the general public for minimum reproduction costs. These groups will naturally gain some additional access to information and analysis simply by virtue of increased services and a higher level of coordination of Federal activities. Under the current materials information arrangements, fragmentation of responsibility is confusing and frustrating to the average individual and group inexperienced in acquiring data. By contrast, integrated capabilities will be located in one office or agency, thus substantially improving its visibility and perhaps accountability to interest groups and the public generally.

This, in turn, will promote public use of materials data and analysis for participating in and influencing the policymaking process. A common data base will provide an improved foundation for communications with political representatives, which will tend to lead toward more informed interaction among relevant actors. Likewise, a shorter response time for requests and the clearinghouse function will be useful to small groups and individuals who cannot easily keep up with current developments. More specifically, certain features, such as the materials life-cycle data, will be of value to particular environmental and industrial groups.

Depending on the alternative, a mix of voluntary and mandatory data submission standards will exist which will not drastically change those currently operative. Thus, in most cases, American industry will continue to exercise a basic choice as to participation through inputs of data it chooses to provide the Government. Other factors held constant, the private sector's participation should not substantially change, and industry will not lose a significant level of influence in the political process. The level of participation by the private sector would not be basically altered, since the agencies with which industry has developed positive relationships would still be performing most of the same materials functions as in the past.

4. Conclusions

Integrated capabilities are likely to contribute to the goal of broader political participation and influence by all public and private groups in American society, Materials information can be an important political resource, and a basis for more widespread political participation by removing some of the obstacles to information access, thus allowing the Nation to better approach the democratic ideal of a broadly-based political system for all those who want to participate. On the other hand, integrated capabilities are unlikely to reduce access and participation by the vast majority of groups which now provide inputs to public policy formulation, although there may be a relative change in the amount of influence these groups exercise. The results of this greater access and usage will be a more informed political exchange among participants, and ultimately a political system which is more responsive and accountable to a variety of groups in American society.

APPENDICES

Appendix A

MATERIALS SUBSTITUTABILITY

A. INTRODUCTION

The possibilities for and potential consequences of substitution are important to all who are concerned with materials supplies and usage. In situations where normal supplies of a material are threatened or constrained, one of the first questions asked is: What is a suitable substitute?

Experience with problems of materials availability, most recently stemming from the shortages of 1973-74. has encouraged users to examine alternative materials and designs. Impacts of those shortages on the national economy have led Government policy makers to inquire about the prospects and effects of substitution as a means of alleviating or avoiding future serious consequences from shortages of essential materials.

For these reasons, the technology assessment examined the information and data requirements of substitution analyses, with a view toward assessing how this capability might be incorporated in a new integrated materials information system. The study examined the following aspects:

- The meaning of the term "materials substitution";
- The information/data required by various classes of decisionmakers for materials substitution decisions;
- The present sources of information/data to make such decisions;
- The gaps in such information and data; and
- The costs involved and the time required for developing the essential system capabilities for substitution analyses.

For purposes of this study the term "materials" is defined very broadly. It includes all substances used by mankind, except food and drugs. Materials are classified in two ways, (1) in accordance with their intended use, and (2) relative to their state of manufacture. The first of these classifications includes the following categories:

- Physical/Structural materials include all substances in raw, semifinished and finished form used in the manufacture of goods, which remain in identifiable form during a period of use. They include: metallic minerals, metals, construction minerals, wood, paper, cotton, wool, plastics, and ceramics.
- Reagents and Intermediates include all substances which are used in the manufacture of a finished product but do not remain as part of it. Such substances generally include chemicals, fertilizers, abrasives, solvents, and industrial gases.
- Energy/Fuels materials include the various mineral fuels and products refined from them, They include: petroleum, coal, natural gas, natural gasoline, and liquified petroleum gases.

The second way to classify materials is according to state of manufacture; major categories include:

- Raw, semifinished, and finished materials includes ores, concentrates, and basic metals and alloys. Also included are agricultural and wood products.
- Components/applications include all parts of consumer and industrial durables. Also included are pesticides, pharmaceuticals and household cleaners, as well as finished grades of petroleum products,
- Systems include all finished household and industrial durables. The term "systems", as applied to energy/fuels and reagents and intermediates, usually refers to the method by which these classes of materials are used.

Table A-1 is a three-by-three matrix using both classification schemes as axes. The argument for classifying materials in these two ways is to consider the possibility that materials substitution may vary among materials classes.

The term "substitution" also needs definition, From the examples given in table A-1, it is clear that the concept of substitution cannot be limited simply to replacing one material with another. Substitution also involves replacing one process with another or changing the functional characteristics of a material or part. Further, these three classes of substitution—material, process, and function-can occur at any of the various stages in the resource, processing, and manufacturing cycle, from raw materials through primary products, parts manufacture, and components to final system design and assembly. Examples of these three classes of substitution are given in table A-z.

Table A–1.-Examples of Substitution Involving Various Classes of Materials

Category of Material, by State of Manufacture	CLASS OF MATERIAL-BY USE		
	Physical/Structural	Reagents and Intermediatedes	En.rgy/Fuels
Raw, Semifinished, and Finished Materials	Alunite for bauxite	Recovered sulfur for Frasch sulfur	Western coal for Eastern coal
	Raw polyester for raw cotton	Natural brines for rock salt	Gasified coal for natural gas
	Alcoa's chloride aluminum reduction process for the Hall process	Mining of natural soda ash for Solvay process soda ash	Fuel oii for natural gas
	Basic oxygen furnaces for open hearth steel-making	Phosphoric acid from furnace phosphorus for wet process acid	Formed coke for metallurgical coke
Components/Applications	New copper alloy for present alloy in auto radiator	Hydrochloric acid pickling for sulfuric acid pickling	Lead-free gasoline for regular
	Aluminum alloy for copper alloy in auto radiator	Direct application to soil of anhydrous ammonia for liquid application of ammonium salts	Propane for fuel oil
Systems	Air-cooled auto engine for water-cooled engine	Not applicable	Geothermal for coal-fired steam boiler
	Mass Transit for automobiles		Solar heating system for natural gas system
	Video phone communications for business transportation		

Table A–2.—Examples of Three Broad Classes of Substitution

One Material for Another	
	Aluminum for Copper in a Bus Bar
	No. 2 Yellow Pine for No. 1 in Woodwork for Home
	Mica-Based for Asbestos-Based Insulation
	Polyester Fabric for Cotton
	Painted Plain Carbon Steel for Stainless Steel
	Aluminum Building Wall Studs for Wooden
	Graphite Golf Club Shafts for Steel/Hickory
One Process for Another	
	Friction Welding of Metal Parts for Butt Welding
	Rolled Threads on Screws for Cut Ones
	Castings for Forgings
	Float Glass for Ground Plate Glass
	Continuous Melt Extraction of Wire for Drawing
One Function or Level of Function for Another	
	Bulk Distribution of Oil Products in Place of Unit Containers
	Elimination of Chrome on Automobiles
	Air-Cooled Engine as a Substitute for Radiators in Water-Cooled Engines

Clearly there is interaction between the three alternatives; replacement of basic material may well dictate process changes throughout the system; process changes may affect the design; design changes certainly lead to new material requirements. But each choice is a separate issue, with its own requirements for information and data. A system providing information and data for substitution analyses must consider each alternative and its needs,

B. DECISIONS AND DECISIONMAKERS

Having defined the kinds of substitution that take place at various levels, from processing of materials to design of final products, it is appropriate to ask: Who makes decisions regarding substitution and why do they consider substitutes?

It is difficult to identify anyone in a free economy who is not involved in the process of making decisions regarding materials substitution, The consumer directly or indirectly dictates most of the choices.

In the chain of decisionmakers who respond in different ways to their perceptions of consumers' choices are two broad classes, Both are potential users of information and data on materials substitution. As shown in table A–3, the first class is Materials Users.

Table A–3.—Potential Users of Information on Substitution

Materials Users	National Policymakers
R&D Personnel	Government Administrators
Designers/Engineers	Congress/Executive Branch
Management/Entrepreneurs	Public Interest Groups
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Everyone in the chain—from raw material producer on-can be considered a Materials User. At the raw materials level, even producers are users of materials in a less refined state, e.g., the alumina producers are users of bauxite. The second class of user consists of public officials and those who influence public policy.

The shortages that developed in the period 1973-74 have tended to overemphasize the need for substitution to overcome shortages, Substitution is continuously taking place to increase the performance and reduce the cost of goods and services,

Four considerations of national interest encourage the development and use of substitute materials:[1]

1. Environmental and safety controls, which have introduced a whole new set of social specifications. creating a need to deal with shortages resulting from prohibited facilities, materials, and processes:

[1]Mineral Resources and the Environment, Appendix to Section 1, Report of Panel on Materials Conservation Through Technology, National Research Council, PB-239580. February 1975.

2. Government intervention in the industrial system to overcome large dislocations such as the combined shortage of electric power and petroleum fuels;

3 Future prospects of dislocations in the flow of materials from sources in developing countries and unstable sources; and

4. The need to reduce reliance on materials of rising cost from foreign sources to balance U.S. payments abroad and control inflation at home,

These and several other examples of motivations for considering substitution are listed in table A-4, They make it clear that substitution is but a special case of materials selection. Materials selection takes place with a particular set of criteria and when another set of criteria is imposed, another selection takes place—the latter being called substitution.

Table A-4.—Examples of Motivations for Substitution

Material Shortage/Potential Shortage
Price/Cost Advantage—Uncertain Future Cost
Higher/Better Performance
Increased Reliability/Decreased Maintenance/Increased Life
Increased Marketability
Skilled Labor Shortages
Fabrication/Production Facility Shortages
Poor Performance of Present Material
Regulatory Actions
Development of Self-Sufficiency
Elimination of Single Source Dependency
Use of Internal Materials
Risk Minimization
Political Advantages
Protection of Domestic Industries
Follow the Competition
Energy Reduction

C. THE PROCESS OF SUBSTITUTION ANALYSIS

DELTA charts[2] have been prepared to show more specifically the information requirements for both materials users and national policy makers. In each chart, information and data needs have been keyed to the various steps in the decisionmaking process.

1. Materials Users

Figure A–1 shows the information requirements for substitution analysis by Materials Users. This DELTA chart shows the logic of a designer/user in one of the manufacturing industries.[3] Rather than explain Figure A–1 in the abstract, the chart will be described by using two current examples—with numbered paragraphs referring to the numbered symbols in the chart.

a. Rear Deck of an Automobile

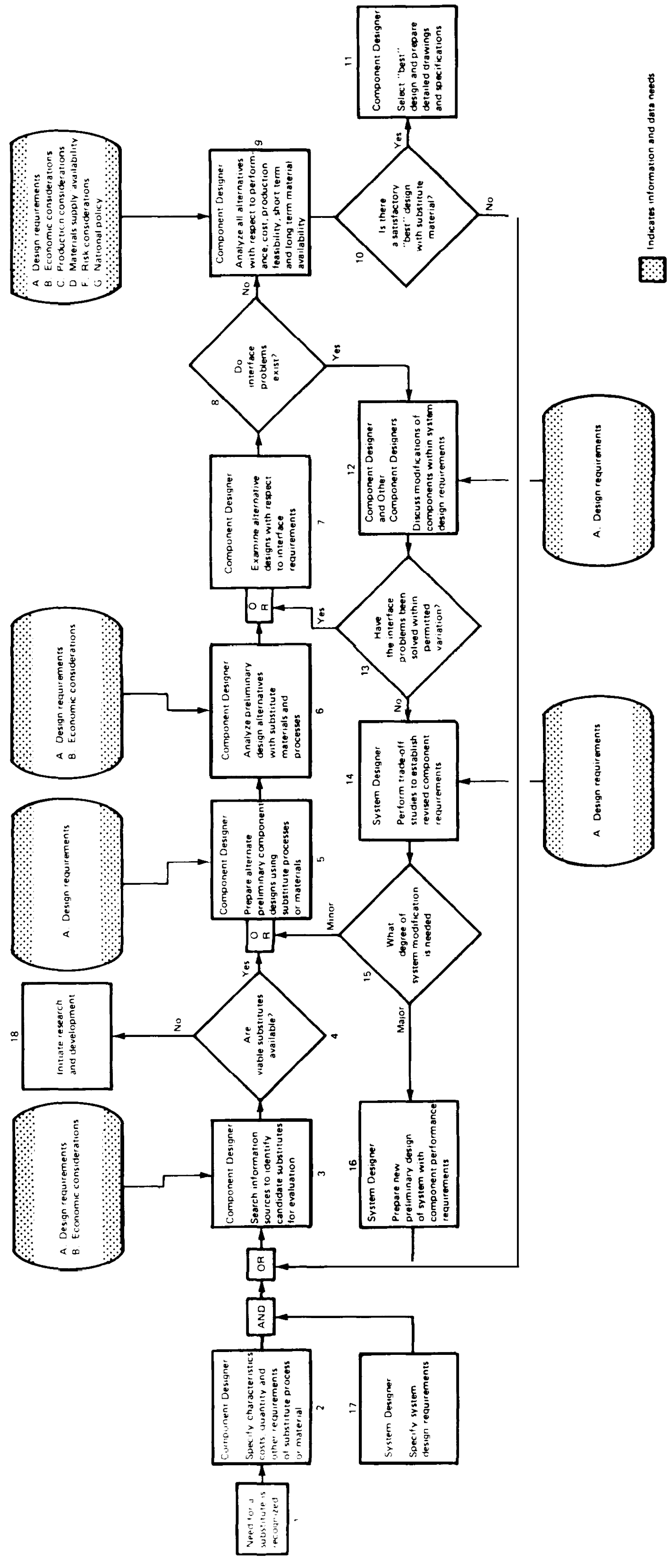
(1) Because supplies of petroleum will be limited and more costly, automobiles will have to be more efficient in their energy usage. One way to reduce the energy used in an automobile is to reduce its weight, It is recognized that the rear deck of an automobile now made of steel might be produced from a substitute material to effect weight reduction,

(2) and (7) The rear deck designer in cooperation with the automobile systems

[2] DELTA charts incorporate a logical network of Decisions, Events, Logic, Time sequence, and Activity. This kind of flow chart shows the major steps in a decision-making process.

[3] A similar chart could be prepared to show the logic of a user/producer in the process industries, for example, a copper company. Such a company looks for another ore body and alternative processes as its current properties are being depleted. Or aluminum companies, in cooperation with the Bureau of Mines, investigate the feasibility of using alunite and other high alumina clays in the production of alumina. Such a diagram would show essentially the logic of raw materials and process selection. The data and information requirements would differ in detail, but the principles used in laying out the decision logic and information requirements would be the same.

Figure A-1. Information Requirements for Substitution Analysis by Materials Users



designer specifies the design requirements for all components, including a lighter weight rear deck. They also specify other desirable characteristics or requirements for the new rear deck. For example, the new material should be formed by equipment in existing production lines with a minimum of modification and the cost should not exceed the cost of a conventional rear deck fabricated from steel,

(3) The rear deck designer next searches for information that will lead him to identify candidate substitute materials, In this search, he wants to specify design requirements and economic constraints, From that input, he would like an information system to identify for him specific kinds and grades of material that meet his requirements, If the component designer specifies only a few of the more important technical performance requirements, he may have a list of candidate materials including aluminum, magnesium, reinforced plastics fiber composites—among others. The components designer on the other hand may specify a large number of technical and economic requirements resulting in no candidate substitutes,

(4) Depending upon how strictly he applies his performance requirements, the rear deck designer either has a long list of substitutes, a few, or none. In this case, we would expect him to have a leading candidate substitute material—aluminum,

(5) The rear deck designer then prepares alternative preliminary designs of a rear deck using aluminum, Some of the problems he faces are inherent in the chemical, mechanical, and physical properties of aluminum as compared with steel, His major information need is for design requirements including properties of materials.

(7) The rear deck designer then examines his alternative designs with respect to the interface requirements of his rear deck and the other components of the automobile that interact with it. For example, if the weight of the rear deck is substantially different when fabricated with aluminum as compared with steel, this may change the suspension characteristics,

(8) He then decides whether or not interface problems exist. In this case, they probably will exist and he must reconcile them.

(12) The rear deck designer and the other component designers get together to discuss the designs of their several components attempting to identify ways in which slight modifications will result in overall compatibility. The information required here is a more detailed analysis of the design requirements as they impinge on the technical performance of each of the components and the whole automobile as a system,

(13) A decision has to be made. Have the interface problems been solved within permitted variation ? If the answer is “yes”, the rear deck designer goes on with his design within the agreed-upon limits,

(14) If the answer is “no”, the problem must be referred to the systems designer who performs trade-off studies to establish revised requirements for rear deck, suspension and other components. He may ask the designer working on the suspension system to modify his design to adapt to the weight of an aluminum rear deck,

(15) At this point, either a major redesign or minor one is initiated. If a major design modification is needed, the automotive systems designer must prepare new preliminary designs for the entire automobile with the performance requirements for each component re-established. On the other hand, if the system modification is relatively minor, the several component designers go back to their drawing boards and work within the newly established variances,

(5) through **(8)** After having reviewed the new interface requirements, the rear deck designer decides that his design is compatible with the other components,

(9) The rear deck designer then analyzes all of his alternative designs—all of which use

alum in urn—with respect to performance, cost, production feasibility, short-term and long-term materials availability, and all other criteria that will ultimately guide a final decision. The information requirements at this point in the analysis are substantial. They include all design requirements and economic considerations guiding the design, They include all information on producibility, labor skills, the availability and use of existing facilities and labor, and energy requirements. They also include forecasts of materials supply and competitive uses for those materials. Such information includes data on production capacities, stockpile levels (where applicable), export-imports, the various forms in which the material will be available, and the delivery time or lead time required.

At this point, the designer will also need information on risks, He will need to assess the legal liability and other risks that he, or his company, might undertake if this design is accepted. Further information related to national policy considerations is needed. Data on the environmental, health, or energy aspects of processing aluminum into a finished rear deck would be applicable,

After all of this information is pulled together and assessed, the designer recognizes a potential limitation on the availability of aluminum. The rear deck represents a substantial increase in the pounds of aluminum per automobile. Forecasts of the availability of aluminum for the automobile industry indicate only marginal availability, which could force a price increase.

(10) When the designer asks, is there a satisfactory "best" design with a substitute?, he may have to answer "no". The supply of aluminum is not assured—in which case, the search for a substitute starts again at Box No. 3. If, on the other hand, an arrangement can be made with an aluminum supplier to assure supplies, the answer may be "yes", In this case, the rear deck designer proceeds with the final selection of the best design and prepares detailed drawings and specifications as indicated in Box No. 11.

b. Coating for an Appliance Part

(1) The need for a substitute is recognized. Rule **66** has been established by the City of Los Angeles and other cities forbidding the use of certain solvents which, in dilute concentrations in air, form eye irritants by photosynthesis.

(2) The component designer specifies the characteristics of a desired coating, its costs, the quantity requirements, and other performance requirements.

(3) The component designer then searches for information that will guide him in the identification of candidate substitute coatings. In this search, he specifies the performance criteria that will be used. He would like to identify coating systems that avoid use of solvents that have been banned. From his information on coating systems, he can identify four alternatives:

(a) Replace the banned solvents with a combination of new solvents that work with existing coating compositions;

(b) Replace the solvent coating by a powder coating;

(c) Replace the solvent coating with a water-dispersed coating system; or

(d) Replace the solvent coating with a radiation-cured coating, wherein the liquid portion becomes a part of the coating film.

(4) It is obvious that there are several viable substitutes available,

(5) The component designer seeks additional information on coating systems performance and costs. Also, he may prepare a number of alternative formulations. He may **test** one or more of his alternatives in the laboratory to substantiate the data that he obtained from his information system.

(6) The component designer then analyzes in a preliminary way the alternative coating systems, based on information available on design requirements and economics.

(7) The component designer next examines alternative coatings with respect to interface requirements —in this case, incompatibility y with adjacent materials.

(8) The question then has to be asked, do interface problems exist, and if the answer is "no", the component designer can analyze his various coating systems with respect to performance, cost, production feasibility, short-run and long-term material availability. In this analysis, he requires a substantial amount of information. It includes design requirements, economic considerations, production considerations, materials supply/availability considerations, risk considerations and even national policy.

(10) He then asks the question, is there a satisfactory "best" design with the substitute coating system included? From the many types of substitution formulations in each of the four options, he undoubtedly can find a satisfactory coating.

2. National Policymakers

Figure A–z presents a DELTA chart showing the information requirements for substitution analysis by National Policy makers. Information requirements for National Policy makers can best be explained by using two current examples of substitution issues at the national level, with numbered paragraphs referring to the numbered symbols in figure A-2.

a. Bauxite

(1) Bauxite is the principal source of alumina from which aluminum metal is produced. In recent years, Jamaica, Surinam, Guyana, and other bauxite-producing countries have met to discuss pricing and other actions. The purpose of these discussions has been to increase revenues from bauxite extraction and sale. Some officials have taken unilateral action to increase the effective price of bauxite being shipped from their countries. Others are pressuring the multi-national aluminum companies to build new alumina and aluminum facilities within their borders to increase the "value added" by manufacture.

All of these actions point to less control by the United States over future supplies and prices of bauxite and other materials produced from it. A need to assess the possibility of substitutes for bauxite is recognized,

(2) The first step following the recognition is to identify all of the end uses of bauxite and develop historical data and projections on the amounts of bauxite required in each end use, About 90 percent of the bauxite consumed in the United States is converted to alumina and about 10 percent is converted directly into abrasives, aluminum chemicals and refractories, Of the alumina produced, about 94 percent is converted directly to aluminum metal and about 6 percent is used in making high-purity abrasives, aluminum chemicals, and refractories.

The end uses for aluminum metal cover a broad range of consumer and industrial goods—autos and other transportation equipment, electrical equipment, construction—to name just a few,

End-use patterns are the province of market research staffs of companies at every level in the materials systems. Valid data are difficult to obtain. Forecasts vary, End-use patterns shift from year to year, depending upon advantages and disadvantages of alternative materials as perceived by users. It is necessary, therefore, to obtain end-use data on all materials used in competition with aluminum, alumina, abrasives, aluminum chemicals, and refractories.

At the raw material level, there is no material in commercial competition with bauxite. R&D is currently under way on developing processes for recovering alumina from alunite and other high alumina clays, Capital and process-cost estimates for such processes are now unreliable,

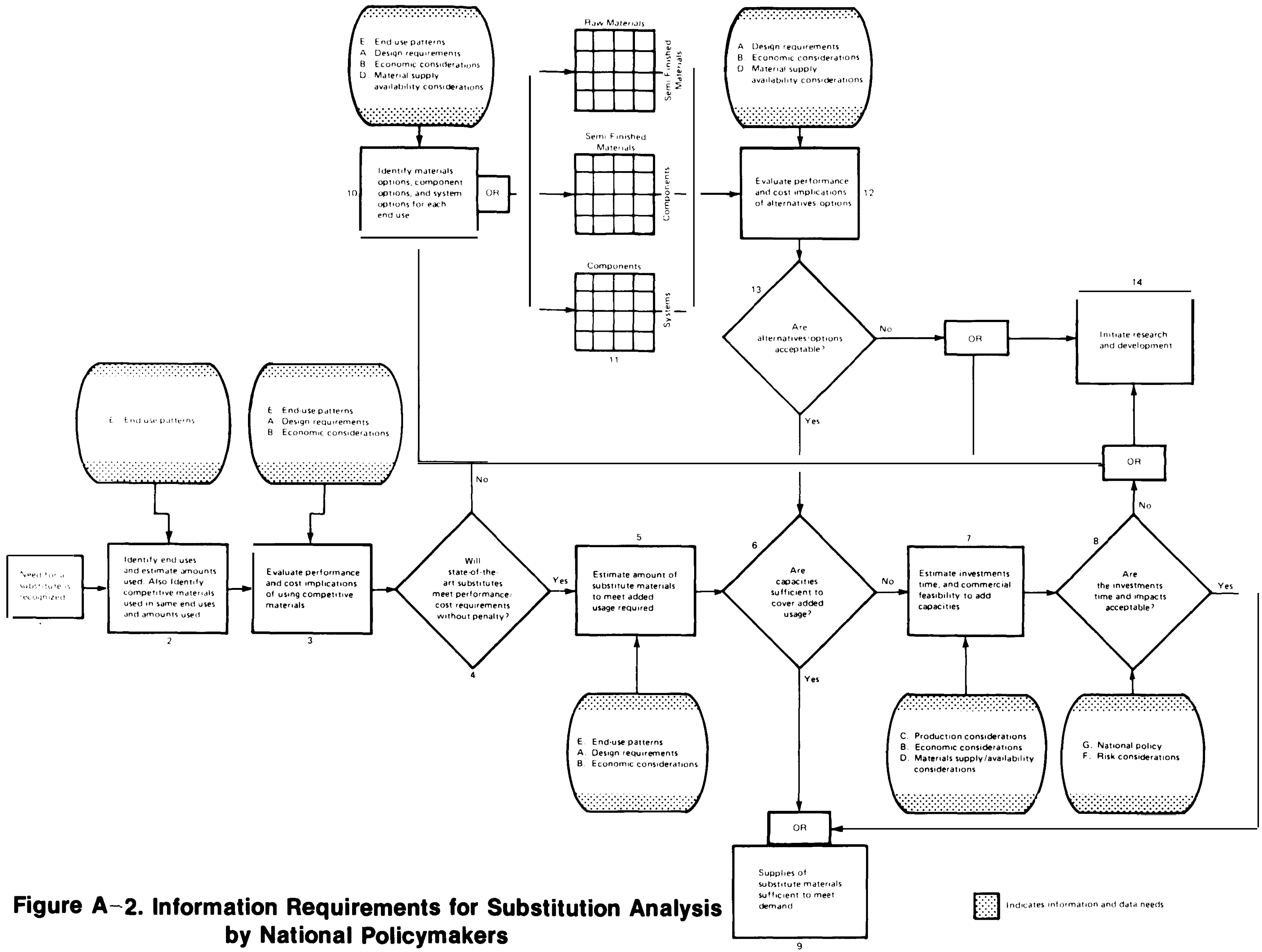


Figure A–2. Information Requirements for Substitution Analysis by National Policymakers

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There are, however, a host of materials currently used in competition with materials produced from bauxite—aluminum metal, aluminum chemicals, abrasives, and refractories. For example, aluminum metal, in most end uses, is in direct competition with one or more of the following-copper, steel, stainless steel, tin plate, magnesium, lead, wood, plastics, rock wool, and fiberglass. The investigator needs to estimate the amounts of competitive materials currently consumed in each use. Little, if any, information and data are available to make such estimates directly. Some information and data are available—but scattered in the minds and files of thousands of people producing and using materials. Furthermore, even if historical data at this level were readily available, the changing technology and changing economics render routine forecasts of future end-use patterns to be of little or no value. This is not to say that useful estimates cannot be made.

(3) In order to estimate the additional amounts of competitive materials that might be used without performance or cost penalties, it is necessary not only to know the amounts now used, but also to have information and data on the design requirements for each use, the properties of competitive materials that might satisfy these design requirements, and the economic considerations that will help shape design. This—in essence—requires knowledge of the design choices made by each of the designers in each of the end uses, where competitive materials were used instead of aluminum and where aluminum was used. Again this information is scattered in the minds and files of designers. Much of the information on design criteria and reasons for choice are considered to be proprietary.

Knowledgeable people in a host of industries can make reasonable estimates of specific conditions of competition between aluminum and competitive materials in specific applications—for example, for storm windows, lawn furniture, automobile engine blocks, automobile body components, etc.

(4) The investigator next asks the question, will state-of-the-art substitutes meet performance and cost requirements without penalty? If the answer is “no”, other options must be sought. This raises a key issue in national policy determination. If substitution is viewed in a simplistic way—one material for another—there is no present commercial substitute for bauxite. If a national emergency were to occur, literally thousands of steps would be taken to find substitutes for aluminum metal, aluminum chemicals, bauxite in abrasives and bauxite in refractories, The logic path following a “no” answer will be discussed later.

(5) If the answer is “yes”, the investigator will then estimate the amount of materials that might be used which are already in competition with bauxite and materials produced from bauxite. In the case of substitutes for aluminum, the estimates will include additional quantities for copper, steel, stainless steel, tin plate, magnesium, lead, wood, plastics, rock wool, fiberglass, abrasives and refractories, Information needed in order to make these estimates includes:

(a) The design requirements for all products made from bauxite and its derivatives, end-use patterns of bauxite and all competitive materials; and

(b) The economic considerations surrounding all of these.

This kind of information is not available in intimate detail; only broad estimates of the amounts of substitute materials can be made. Furthermore, there are competitive pressures among companies which limit data availability. No one company or industry has a significant fraction of the data that would be needed by an analyst not familiar with the technology and the wide spectrum of industries involved. Even if valid historical data were available, forecasts of future usage depend in part upon the acceptance of the substitutes by industrial and home consumers.

(6) If additional quantities of state-of-the-art substitutes can be used, the question must be asked: are capacities sufficient to cover the added usage? if the answer is "yes", the substitution analysis is complete and Box 9 indicates that supplies of substitute materials are sufficient to meet the demand. If the answer is ''no', an additional investigation is needed,

(7) If capacities are not sufficient, it is possible to make additional investments in facilities for producing the substitute materials, This step involves detailed estimates of the investments required, the time needed and the commercial feasibility y of adding capacities of all of the various state-of-the-art materials for which there is insufficient capacity, This kind of information is not readily available. Estimates, however, can be made, depending on the likely location, availability and costs of raw materials, transportation charges for raw materials, availability and costs of energy, etc.

(8) The investigator then asks the question: are the potential investments in dollars and time acceptable, and are the various impacts also acceptable for adding capacities of these state-of-the-art materials? If the answer is ''no' new options must be sought and that will be discussed in the next paragraph. If the answer is "yes", the supplies of substitute materials can be made available within an acceptable time to meet the demand. The policy analysis would be completed.

(10) If state-of-the-art substitutes are not available, the impacts of building new capacity are unacceptable and it is necessary to identify other substitution possibilities, This requires searching for materials options, components options, and systems options for each end use, Here again, information is needed on end-use patterns, design requirements, economic considerations regarding each of the end uses, and materials supply and availability. At the raw material level, there is no state-of-the-art substitute for bauxite, At the component level, there are a wide variety of substitute materials that approach the performance and cost requirements of the various end uses, but with varying degrees of penalty.

(11) The detailed information on materials options, component options, and systems options for each end use is made explicit in any array so that the relationships among all alternatives/options can be assessed.

(12) It is necessary for the investigator now to evaluate the performance and cost implications of all of the alternatives/options. Although figure A-2 indicates that design requirements, economic considerations and materials supply/availability considerations are taken into account, it is exceedingly difficult to get data at a sufficiently disaggregate level to make estimates of all of the options. Useful estimates however can be made.

(13) After the information has been assembled and evaluated, the question must be asked: are the available alternatives/options acceptable? —if the answer is "no", the investigator must return to Box 10 to identify additional materials options, component options, systems options, or he must go on to Box 14, initiate research and development. If, on the other hand, the answer is "yes", the investigator asks the question: are the capacities of the substitute materials sufficient to cover the added usage?—and the remainder of the analysis proceeds as indicated before.

b. Coal for Petroleum Products

(1) The unilateral action by OPEC members has increased the United States negative balance of payments in energy by over **$20** billion per year. A need for a substitute for foreign petroleum has been recognized.

(2) The first step undertaken by the investigator is to identify end uses of petroleum products and to estimate the amounts used in each of the end uses. It is also necessary to identify the competitive materials that are used in the same end uses and the various amounts used. The primary material used in competition with foreign petroleum is domestic petroleum. Further, petroleum from all sources supplies virtually all of the energy

required for automotive and other transportation devices In other uses, such as space heating, process steam and central power station production of electric power, petroleum products are in competition with coal, natural gas, and uranium. Petroleum and natural gas provide feedstock for making plastics and synthetic fibers.

(3) Based on the end-use patterns and the design requirements for energy in each of the end uses, and the economic considerations, it is necessary to evaluate the performance and cost implications of using domestic coal, uranium, and natural gas. It is here that the current policy considerations of energy bog down. There is no agreement on the performance and cost implications of using alternative energy systems for the next 20 to 30 years. Businessmen, however, investing stockholders' money must make decisions today that will be considered prudent throughout the lifetime of the investment.

The options for substituting coal or other materials for feedstocks must be considered in R&D.

(4) At this point, the investigator needs to ask the question: will the state-of-the-art substitute coal meet the performance and cost requirements without penalty? Depending upon the projection of cost and performance, the answer is "yes", there is plenty of coal and the performance and cost requirements involve inconsequential penalties, Or the answer is "no", and we must rely on solar and other forms of energy.

(5) If the answer is "yes", it is necessary to estimate the amount of substitute materials that will meet the added usage requirements. The capacity in the United States for mining coal is limited. The amount of coal being mined now is not much more than was mined 20 years ago. The reserves of uranium are limited.

(6) The investigator must then ask the question: are capacities sufficent to cover the added usage?—and the answer is obviously "no."

(7) The investigator needs then to estimate the investments in time and commercial feasibility of adding coal and uranium mining capacity sufficient to meet energy demands. These investments include not only design and development of mines, but also design and construction of facilities to burn coal and handle it in an environmentally acceptable way. They also of course include design and development of nuclear facilities that are environmentally acceptable.

(8) The investigator now asks the question: are the investments of time and impacts acceptable? Most would agree that coal and uranium cannot, in the near term, replace all of the energy needs now satisfied by imported oil.

(10) The next step is to identify materials options and other systems options for each of the end uses of petroleum. This involves options relative to increasing the supplies of natural gas from domestic sources. It includes solar, geothermal, breeder and fusion energy, Some of these options can be installed today at a rather substantial penalty. All options, however, have to be evaluated in light of their effectiveness, cost, and penalties over a 20- or 25-year period.

(11) The relationships among all of the options from raw materials through alternative systems are made explicit.

(12) The investigator next evaluates the performance and cost implications of all of the alternatives/options.

(13) Based on the above evaluation, the investigator asks the question: are any of the alternatives/options acceptable ?—if the answer is "no", there is the need for research and development. And, if the answer is "yes", the next step is to examine the question: are capacities of those substitute materials sufficient to cover the added usage ?—and the analysis goes on,

D. INFORMATION REQUIREMENTS FOR SUBSTITUTION ANALYSIS

The type, amount, and specificity of information required by the two identified potential user groups—the Materials Users and the National Policy makers—for making substitution analyses varies over a wide range.

Complexity of the substitution selection process occurs at all levels. For example, a designer seeking a substitute material may consciously recognize that only one or two factors are important in his selection process. In choosing a substitute for stainless steel tubing in a chemical processing plant, he may consider only high-temperature corrosion as being the important requirement for the material. But, obviously, he must also take into account such other requirements as the cost of the material, its availability, whether it can be welded, and so on. Although many of these requirements appear to be quite obvious, they would require precise definition for any information system to assist the designer in his selection. Likewise, a National Policy maker must consider a multitude of technical, economic and political factors in making decisions involving materials substitution, Some of these also might be obvious, such as assurance that an unexpected war would not be initiated because of a substitution decision (it has been suggested that the lack of substitutes for chromium may have played a key role in causing Germany to enter WW 11), However, other factors such as the extent of disruption to the economy or to a particular class of workers that might occur by employing the substitute are perhaps more difficult to ascertain. Table A–5 offers a listing of information/data identified in this study as required by the two user groups in making substitution decisions. These have been categorized into seven broad classes, coinciding with those shown in figures A-1 and A-2.

It is possible to compare both user groups with their particular information needs, and to consider whether such categories of information (and data) can appropriately be included in responsive materials information systems. In many instances, it is recognized that such information must come from outside the "system", that is, be provided as "a priori" to an inquiry to the "system". In table A-5, the notation "I" has been used for information items required, and possible to be included in the system; "O" indicates those items essential to decisions, but probably obtained from outside sources; and "N" designates those items generally not required by the particular user group.

Some of the information items in table A-5 are self-explanatory; however, a few comments are in order to explain some that aren't quite so obvious.

Under the category "Design Requirements", the first listed item—"Customer Acceptance"—is identified as the starting consideration by Materials Users in essentially all substitution analyses. If a judgment is made that the market is not likely to accept the substitute, all further consideration generally is terminated. Although this item is of high importance for the Materials-User group, such information either is so specific to the individual substitution or is so judgmental. the information most likely would not be found within the formalized information system. And as a result it would have to be obtained

[4]As used here data are specific facts, usually numerical, quantitative, measurable. Examples are the properties of materials, the populations of cities, the dimensions of land masses. Being primarily numerical, data are fairly readily stored and manipulated in automated systems, Information is the broader class of knowledge. encompassing judgments, experience, art. behavioral (considerations, etc. Examples include directions on how to do something, expressions of policy. social considerations, esthetics, alternatives. Because it is expressed in words, the broader aspects of ' in format ion' are more difficult to mechanize. Data are a category of information. These cons iderat ions are significant when one contemplates the implementation of an automated information system,

Table A-5.—Information Requirements for Substitution Analysis

	Materials Users	National Policy-makers
A. DESIGN REQUIREMENTS		
Customer Acceptance		
Esthetics	0	N
Personal Bias	0	N
Market Acceptability	0	N
Performance Criteria	0	0
Materials Performance		
Mechanical Properties	I	N
Chemical Properties	I	N
Physical Properties	I	N
Fabricability	I	N
Machinability	I	N
Toxicity	I	N
Ease of Joining	I	N
Corrosion, Oxidation, and Fire Resistance	I	N
Compliance with Specifications and Codes		N
Protection Against Misuse	0	N
Vandalism Protection	0	N
Reuse/Recyclability /Disposal	I - o	I-o
Compliance with Specifications and Codes	I-O	I-O
Reliability and Maintainability	I - o	I-O
B. ECONOMIC CONSIDERATIONS		
Material Cost	I	I
Cost/Price Stability	I	I
Transportation Coats	1--0	10
Marketing Costs (to use substitute)	0	N
Production Costs	0	I-o
Investment Required to Incorporate		I-o
Life-Cycle Costs	0	0
Tariffs and Taxes	I-O	I
C. PRODUCTION CONSIDERATIONS		
Availability of Fabrication Facilities	I-o	I
Availability of Labor (specific skills)	I-o	I
Production Rates Achievable	0	I
Time Required to Incorporate Substitute	0	I - o
Use of Existing Facilities and Labor	I	I - o
Energy Requirements	I-o	I
Inspectability	0	N
D. MATERIALS SUPPLY/AVAILABILITY CONSIDERATIONS		
Supply - Present and Future, Current and Potential		
Resources/Reserves	I-O	I
Stockpile Level	t-o	I
Imports/Exports	I-o	I
Defense Allocation	I-o	I
Inventories	I-o	I
Supply Assurance (including trade agreement)	0	I - o
Identity and Location of Supplies	I	I
Forms of Materials Available	I	I
Delivery Time (Lead Time)	I-o	I
E. END-USE PATTERNS - Historical and Projected	I-o	I
F. RISK CONSIDERATIONS		
Legal Liability	0	N
Technical/Professional	0	N
Business		
Political	0	0
G. NATIONAL POLICY CONSIDERATIONS		
Regulatory Agency Compliance (Federal, State, local)		
Environmental	I-o	I
Health/Safety	I-o	
Energy	I-o	;
Economic Impacts of Using Substitutes	I-- O-N	I
Political Impacts of Using Substitutes	O-N	o

I = required and possible in system (hard data, either technical or economic).

O = required but obtained outside system

N = generally not required by user group.

from outside the system. Further, it is interesting to note that, although this item is important to Materials User decisions, it is considered to be of little significance in substitution decisions made by National Policy makers. It should be noted that many differences, such as those mentioned above were found in the information required for the two user groups.

The listed items regarding "Materials Performance" obviously are required by the Materials Users, but evidence indicates they are not required by the National Policy makers. And, although these items are required by the Materials Users, the degree of specificity of each item that is required will vary significantly from one substitution analysis to another. Also, in some analyses the requirements are easily stated (including the range over which the performance can vary and still maintain acceptability). whereas in others the requirements may not even be known with sufficient specificity to allow the substitution decisionmaker to ask the information system the necessary questions. As an example, a recent study involved the assessment of plutonium as a power source for an implantable heart pacemaker, the motivation being significantly increased life and reliability. In addition to consideration of some of the performance requirements listed, it became apparent in the assessment that the plutonium source required unique packaging that included its being fire resistant and bullet proof. Although these were criteria which were not considered in the original analysis, they became of critical importance when the consequences of the plutonium source being in a fire (during cremation, if not removed first) or accidentally or intentionally being struck by a bullet, were recognized.

The item of "Compliance with Specifications and Codes" in the listing under "Materials Performance" refers to compliance of the material (e.g., ASTM specifications)—these same words are listed later under "Design Requirements" where they refer to compliance of the system which is made from the materials, Although this information is considered required by the Materials User, it has been judged as not being required by the National Policy makers. It is believed that specifications and codes would not be deterrents to policy decisions, for, if they were, the Policy maker would simply see that the specifications and codes were changed.

The item "Protection Against Misuse" is best explained by example. Polyethylene bags proved to be a highly successful substitute for paper ones (e.g., for dry cleaning); however, when they began being used in baby beds and several deaths from suffocation resulted, a large campaign was conducted to educate consumers not to misuse the product.

"Economic Considerations" are, of course, required by both user groups, but again. the level of detail required would vary for the two groups and for each analysis. The item of "Marketing Costs" refers to the cost of convincing consumers the substitute will satisfy their needs. Consider, for example, the difficulty the automobile manufacturers have had in convincing the public that fiberglass automobiles are as safe as metal ones. National Policy makers most likely would not be concerned with market factors of this type.

The item identified as "Investment Required to Incorporate" relates to how much capital would be required to develop the needed technology for the substitute and then to incorporate it into the economy. An example is the previously mentioned proposed substitution of alunite for bauxite as an ore for aluminum, Although the essential technology exists for this substitution, large investments would be required to make it a reality and knowledge of the magnitude of these commitments would be required by the various decisionmakers in their assessment of whether or not to proceed with this substitution.

Certain items relating to "Production Considerations" are required by both user groups. If the facilities required by the substitute are not available within a producing facility, the substitution may not be acceptable to the individual company, On the national policy level, the availability of facilities within the country may determine the acceptability y of the substitute. The same considerations also apply to the availability of labor with specific skills, For example, widespread substitution of coal by gas and oil during the recent past may not have occurred if the magnitude of the plight of the coal miners could have been predicted. On a Materials-User level, it is unlikely that a company would change from producing a cast part to using a welded one, if they already had the skilled labor for making castings and could foresee a problem in acquiring the needed welders.

Recent difficulties in obtaining energy have vividly pointed out the necessity of including this factor in any substitute selection process. This not only relates to the amount of energy required but also to the type. The gas shortages in various parts of the country have caused changes to other forms of energy, and this in turn has caused numerous substitutions to be made in products or processes.

A recent experience can be used as an example of the necessity for "Inspectability". A change in material, coupled with a change in heat treatment, was recently recommended for use in a high-volume automotive part. The part, because of its function, required rather complete inspection for internal defects-which could only be accomplished reliably by ultrasonic techniques. Although the recommended substitution met essentially all other requirements, because of its structure, ultrasonic waves would not pass through it. Therefore, the substitute was judged unacceptable.

Regarding "Materials Supply/Availability", most of the information identified as being required for substitution analyses would most likely be included in a national materials system. An exception might be "Supply Assurance", particularly at the Materials User level, This is because many of the factors which influence the assurance of supplies are interpersonal relationships that might exist between the supplier and the consumer which, although very significant, certainly could not be included in a new integrated materials information system.

It has been judged that a system must include "Identification and Location of Supplies". This suggests an index of all materials producers and supplies. Also included should be their supply and production capacities. The "Forms of Materials Available" should, ideally, be keyed to the supplier in the system. "Delivery Time" data presently is tabulated by various groups within industry (e.g., Aerospace Industries Association) and Government (NAVSEA) and would constitute a key factor in the decisionmaking process regarding substitute selection.

As indicated in the DELTA charts, the starting point for considering substitution by national policy makers would be a determination of "End-Use Patterns", current, historical, and future. Ideally, this would require information on all the products that are made from each material and the amounts of the materials consumed by each use. Such information often is proprietary and of limited availability.

Substitution decisionmaking is affected strongly by the amount of "Risk" that the various decision makers involved in the selection process are willing, or are forced, to accept. Essentially all substitution decisions have some degree of risk associated with them, but the intensity of the risk and the factors causing the risk vary significantly. Risk can be tied to the "Legal Liability" that is associated with the end use of the item, i.e., the consequences that can arise from failure, use or misuse of the item, For example, selection of a material for a critical airplane component would have high risk, whereas the choice of a paint for an office desk would have low risk.

Risk also may be described as being "Technical or Professional", i.e, how the quality of the substitution selection decision reflects on the decisionmaker's technical and/or professional reputation. If loss of one's job is the "reward" for a wrong decision, that risk is high! And, this might occur to both the person selecting the desk paint and the one selecting the material for the critical aircraft part. Further classifications of risk are "Business" risk, which is associated with the effect of the substitution decision on profitability (e.g., the amount of money affected by how the substitution decision turns out) and "Political" risk, which is associated with the potential political ramifications of the decisions (e.g., how seriously will a substitution decision affect our relationship with another country—will it lead to war?).

Considerations of "National Policy", such as compliance of the substitute with regulatory agencies' policies, have become increasingly more important in recent times; and these agencies exist on all levels—Federal, State and local. For example, a technically acceptable substitute for mica for certain high-temperature insulating applications might be asbestos, but the environmental problems associated with the use of asbestos probably would cause it to be ruled out as a possible substitute material.

Although the National Policy maker will be concerned with the effects of the substitution on the economy, a Materials User's attention to the effect on the national economy perhaps will vary from a similar concern to essentially none at all, depending on the size of his company, the amount of material involved in the substitution, and on his national responsibility. This also holds true for considerations of the "Political Impacts" of the substitution. Although this aspect might be of little concern to the Materials User, the specific choice of a substitute material could have a severe political impact. Consider, for example, the decision to find substitutes for Middle-East oil-e. g., the development of self-sufficiency and the encouragement to reduce consumption (a defined form of substitution) and the effect such a decision would have on OPEC countries.

Tables A-6 and A–7 restructure the listing of information requirements from table A–5, identifying separately the information needs of the two user groups; these are categories of information/data that can be included in an improved materials information system. These listings are not intended to be exhaustive and certain individual items could be disputed. However, the primary intent of the list is to provide an identification of the significant items required by materials users.

Table A-6.—Information Requirements for Substitution Analysis: Those Specifically Required by Materials Users are Underlined

A. DESIGN REQUIREMENTS

Customer Acceptance
- Esthetics
- Personal Bias
- Market Acceptability

Performance Criteria

Materials Performance
- Mechanical Properties
- Chemical Properties
- Physical Properties
- Fabricability
- Machineability
- Toxicity
- Ease of Joining
- Corrosion, Oxidation and Fire Resistance
- Compliance with Specifications and Codes

Protection Against Misuse

Vandalism Protection

Reuse/Recyclability/Disposal

Compliance with Specifications and Codes

Reliance and Maintainability

B. ECONOMIC CONSIDERATIONS

Material Cost

Cost/Price Stability

Transportation Cost

Marketing Costs (to use substitute)

Production Costs"

Investment Required to Incorporate

Life-Cycle Costs

Tariffs and Taxes

C. PRODUCTION CONSIDERATIONS

Availability of Fabrication Facilities

Availability of Labor (specific skills)

Production Rates Achievable

Time Required to Incorporate Substitute

Use of Existing Facilities and Labor

Energy Requirements

Inspectability

D. MATERIALS SUPPLY/AVAILABILITY CONSIDERATIONS

Supply—Present and Future, Current and Potential
- Resources/Reserves
- Stockpile Level
- Imports/Exports
- Defense Allocations
- Inventories

Supply Assurance (Including trade agreements)

Identify and Location of Supplies

Forms of Materials Available

Delivery Time (Lead Time)

E. END-USE PATTERN-Historical and Projected

F. RISK CONSIDERATIONS
- Legal Liability
- Technical/Professional
- Business
- Political

G. NATIONAL POLICY CONSIDERATIONS

Regulatory Agency Compliance (Federal, State, local)

Environmental

Health/Safety

Energy

Economic Impacts of Using Substitutes

Political Impact of Using Substitutes

Table A-7.—Information Requirements for Substitution Analysis: Those Specifically Required by National Policymakers are Underlined

A. DESIGN REQUIREMENTS

- Customer Acceptance
  - Esthetics
  - Personal Bias
  - Market Acceptability
- Performance Criteria
- Materials Performance
  - Mechanical Properties
  - Chemical Properties
  - Physical Properties
  - Fabricability
  - Machinability
  - Toxicity
  - Ease of Joining
  - Corrosion, Oxidation, and Fire Resistance
  - Compliance with Specifications and Code
- Protection Against Misuse
- Vandalism Protection
- Reuse/Recyclability/Disposal
- Compliance with Specifications and Codes
- Reliability and Maintainability

B. ECONOMIC CONSIDERATIONS

- Material Cost
- Cost/Price Stability
- Transportation Cost
- Marketing Costs (to use substitute)
- Product ion Costs
- Investment Required to Incorporate
- Life-Cycle Costs
- Tariffs and Taxes

C. PRODUCTION CONSIDERATIONS

- Availability of Fabrication Facilities
- Availability of Labor (specific skills)
- Production Rates Achievable
- Time Required to Incorporate Substitute
- Use of Existing Facilities and Labor
- Energy Requirements

D. MATERIALS SUPPLY/AVAILABILITY CONSIDERATIONS

- Supply—Present and Future, Current and Potential
  - Resources/Reserves
  - Stockpile Level
  - Imports/Exports
  - Defense Allocation
  - Inventories
- Supply Assurance (Including Trade Agreement)
  - Identify and Location of Supplies
  - Forms of Materials Available
  - Delivery Time (Lead Time)

E. END-USE PATTERN&Historical and Projected

- Supply-Present and Future, Current and Potential
  - Resources/Reserves
  - Stockpile Level
  - Imports/Exports
  - Defense Allocation
  - Inventories
- Supply Assurance (Including Trade Agreement)
  - Identity and Location of Supplies
  - Forms of Materials Available
  - Delivery Time (Lead Time)

F. RISK CONSIDERATIONS

- Regulatory Agency Compliance (Federal, State, Local)
  - Environmental
  - Health/Safety
  - Energy
- Economic Impacts of Using Substitutes

Close examination of these tables establishes the most significant findings of this study, namely that the scope of substitution analysis is so broad that it calls on information covering virtually every aspect of the materials cycle. In effect, the information requirements for substitution studies are no different than they are for materials selection or, more generally, for overall materials policy analysis.

The implications of this are several. First, substitution analysis is hindered by the same deficiencies in the existing materials information system that impede policy analysis. The deficiencies with respect to policy makers' requirements (as developed above) appear to be worse than for materials users, but both are severe. Second, modifications to the existing system that are designed to improve its support for policy analysis will also make it more capable for substitution studies. In so far as this brief study can evaluate the additional costs and time needed to include the capability for substitution analysis in a generalized new integrated materials information system would be negligible.

Appendix B
ACRONYMS

AFM	Aluminum Forecasting Model (GSA)
ARPA	Advanced Research Projects Agency (DOD)
BEA	Bureau of Economic Analysis (DOC)
BEAFPM	Bureau of Economic Analysis Fiscal Policy Model
BEAIO	Bureau of Economic Analysis, Input/Output Model
BEAQM	Bureau of Economic Analysis Quarterly Model
BESOM	Brook haven Energy System Optimization Model
BLM	Bureau of Land Management
BOC	Bureau of Census
BOM	Bureau of Mines
BOR	Burefau of Reclamation
CACM	Copper-Aluminum Competition Model
CAIDM	Copper-Alum inure Industrial Dynamic Model
CDB	Commodity Data Base (BOM)
CIAS	Contingentcy Impact Analysis System (GSA)
CMIDM	Copper Market Industrial Dynamics Model
CPCM	Commodity Production Cycles Model
CPPM	Cost-price pressure Model (DOC)
CRIB	Computerized Resource Information Bank (USGS)
CRS	Congressional Research Service
DB/DC	Data Base/Data Communications
DDC	Denfense Documentation Center (DOD)
DEMOS	Demographic Economic Modeling System
DESM	Dynamic Energy System Model
DIBA	Domestic and International Business Administration (DOC)
DOA	Department of Agriculture
DOC	Department of Commerce
DOD	Department of Defense
DOD/IAC	Department of Defensfe Information Analysis Center
DOI	Department of the Interior
DOT	Department of Transportation
DNRUM	Dynamic Natura1 Resource [Utilization Model
EEPPM	Energy Employment Pollution Policy Model
EETM	Economic-Environmenta1 Tradeoff Model
EFRM	Energy Faci1ities and Resources Model
EFS	Economic Forecasting Service
EMPIS	Engineering Materia1s and Processes Information System (GE)
EM(JS	Energy Model for the: United States
EPA	Environmental Protection Agency
EQM	Energy Quality Model (ERDA)
ERDA	Energy Research and Development Administration
ERS	Economic Research Service (USDA)
FAS	Foreign Agricultural Service (USDA)
FAS	Fuels Availability System (BOM)
FEA	Federal Energy Administration
FEILS	Federal Energy Information Locator System (FEA)
FMS	Federation of Materia1s Societies
FPC	Federal Power Commission
FREPAS	Forest Range Environmental Production Ana1ytica1 System (USDA)
FS	Forest Service

GAO	U.S. General Accounting Office
GIOM	Generalized Input/Output Model
GNP	Gross National Product
GSA	General Services Administration
GWU	The George Washington University
IIASA	International Institute for Applied Systems Analysis
INFONET	GSA Teleprocessing Network
INFORM	In formation for Forest Management (USFS)
INFORUM	Interindustry Forecasting Model-University of Maryland
1/0	Input/Output
LANDSAT	Earth Resources Technology Satellite (formerly ERTS)
LP	Linear Programming
MANERGY	Energy Management Model for the United States
MAS	Minerals Availability System (BOM)
MCIC	Metals and Ceramics Information Center
MEM	Metal Endowment Model
MILS	Minerals Industry Location System (BOM)
MITI	Ministry of International Trade and Industry (Japan)
MRIO	Multi-Regional Input/Output Model (DOT)
MRS	Materials Referral Service (concept)
NAE	National Academy of Engineering
NAS	National Academy of Sciences
NASA	National Aeronautics and Space Administration
NBS	National Bureau of Standards
NCDB	National Coal Data Base (USGS)
NEDS	National Environmental Data System (EPA)
NEIC	National Energy Information Center (FEA)
NIRAP	National Interregional Agricultural Projection System (USDA)
NIST	National Information System of Scientific and Technical Information (Japan)
NMAB	National Materials Advisory Board (NAS)
NRC	National Referral Center (Library of Congress)
NSEM	National Socio-Economic Model
NSF	National Science Foundation
NSRDS	National Standards Reference Data System (NBS)
NTIS	National Technical Information Service (DOC)
OBRA	Office of Business Research Analysis (Commerce)
OECD	Organisation for Economic Cooperation and Development
OEDB	Official Estimates Data Base (SRS-USDA)
OEP	Office of Emergency Preparedness
OGDB	Oil and Gas Data Base (USGS)
OMPD	Office of Minerals Policy Development (DOI)
ORCHIS	Oak Ridge Hierarchal Information System (ERDA)
OTA	Office of Technology Assessment
PIES	Project Independence Evaluation System (ERDA)
PRS	Petroleum Reporting System (FEA)
QMCWEM	Queen Mary College World Energy Model
RANN	Research Applied to National Needs
READY	Attack Simulation and Damage Assessment Model (GSA)
RFFM	Resources for the Future Model (EPA)
RIS	Regulatory Information System (FPC)
ROPE	Runout Production Evaluation Model (DOC)

SAM	Shortage Allocation Model (DOC)
SEAS	Strategic Environmenta1 Assessment System (EPA)
SIC	Standard Industrial Code
SIMIS	Stockpile Inventory Management Information System (GSA)
SRS	Statistical Reporting Service (USDA)
SSIE	Smithsonian Scientific Information Exchange
TPECM	Tax Policy and Energy Conservation Model (EPA)
TVA	Tennessee Valley Authority
UN	United Nations
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WAIF	Wharton Annual and Industry Forecasting Model
WIM	World Industry Model
WORLD3	Limits to Growth Model
WRIO	World Regional Input/Output Model

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