Volume II
Appendix D.1
STS-107 Training Investigation

The Board conducted a thorough review of all training activities that were performed in preparation for STS-107, including training conducted for the crew, launch controllers, and mission controllers. An analysis of STS-107 Orbiter and payload training requirements was conducted, as well as a complete review of all training records, schedules, instructor logbooks, and related documentation for the crew, flight controller, and launch controller training. Interviews and discussions were held with STS-107 training and operational personnel at both Johnson and Kennedy Space Centers to investigate the STS-107 training process, the effect of launch slips, the performance of the crew, flight controllers, and launch controllers, and the flight readiness of all for the STS-107 mission. Although several issues were identified as a result of this investigation, none were considered causal in the loss of *Columbia*.

The investigator who wrote this report proposed four recommendations, one of which was adopted by the Board for inclusion in the final report. The conclusions drawn in this report do not necessarily reflect the conclusions of the Board; when there is a conflict, the statements in Volume I of the Columbia Accident Investigation Board Report take precedence.

STS-107 Training Investigation

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SUMMARY

On February 1, 2003, at 07:59 Central Standard Time, the Space Shuttle *Columbia* broke apart during entry killing all seven crewmembers of mission STS-107.

As part of the ongoing investigation into the cause of the *Columbia* mishap, all aspects of training for mission STS-107 were examined. An analysis of STS-107 Orbiter and payload training requirements was conducted, as well as a complete review of all training records, schedules, instructor logbooks, and related documentation for the crew, flight controller and launch controller training. Interviews and discussions were held with STS-107 training and operational personnel at both Johnson and Kennedy Space Centers to investigate the training process, the effect of launch slips, the performance of the crew, flight controllers, and launch controllers, and the flight readiness of all for the STS-107 mission.

The following report provides an overview of the Space Shuttle mission training process, summarizes the factual information about STS-107 mission training, describes the investigative process used in assessing this information, and presents an analysis of that training. This investigation determined that the crew and controller training for STS-107 was not a contributing factor in the loss of *Columbia* and the STS-107 crew.

1.0 TRAINING OVERVIEW

Training for a Space Shuttle mission begins when a new operator is hired. Space Shuttle operators are the astronauts who fly onboard the Space Shuttle, the launch controllers who work the Launch Control Center (LCC) during launch, and the flight controllers who monitor in the Mission Control Center (MCC) from the vehicle clearing the launch tower until landing.

1.1 SPACE SHUTTLE OPERATORS AND MISSION RESPONSIBILITIES

1.1.1 Crew

A Space Shuttle crew is comprised of pilot astronauts and Mission Specialist astronauts. Payload specialists are "guest astronauts" and may also be assigned to a mission if there is a requirement.

Pilot astronauts may be either a shuttle mission commander (CDR) or a shuttle mission pilot (PLT). They are usually chosen for their extensive flight experience or background as military test pilots. During a mission, the CDR has onboard responsibility for the vehicle, crew, mission success, and safety of flight. The CDR sits in the left seat on the flight deck during ascent and descent. The PLT assists the commander in controlling and operating the vehicle during all phases of flight. The PLT sits in the right seat on the flight deck during ascent and descent. Before being eligible to serve as a mission commander, a pilot astronaut must serve on a shuttle mission in the pilot position at least once.

Mission specialist astronauts are typically scientists or engineers specializing in areas such as aerospace engineering, physics, chemistry, astronomy or medicine. Mission Specialists (MS) are trained in the details of all Orbiter onboard systems, as well as the operational characteristics, mission objectives, and supporting equipment for each of their assigned missions. Mission Specialists perform extravehicular activities (EVA), or space walks, operate the Remote Manipulator System (RMS), and are responsible for payloads and specific experiment operations. One MS is designated as MS2, or flight engineer, for the mission. The MS2 is an integral part of the flight deck crew, assisting the commander and pilot in controlling and operating the vehicle during all phases of flight. At least two MS are chosen to receive extravehicular activity training (EVA) for each mission regardless of whether there is an EVA scheduled for the mission. These EVA crewmembers are trained for Space Shuttle contingencies that would require crewmembers to perform a spacewalk, such as manually closing the payload bay doors should they fail using the normal methods. These

MS are designated EV1 and EV2. Another crewmember, designated "IV," trains to support the EVA crewmembers in donning and doffing their suits and helps coordinate the EVA activities from inside the vehicle.

Payload specialists are persons other than NASA astronauts (including international citizens) who have specialized duties that may be added to shuttle crews if activities that have unique requirements. If Payload Specialists are required, NASA, the foreign sponsor, or the designated payload sponsor nominates them. Although Payload Specialists are not part of the Astronaut Program, they must have the appropriate education and training related to the payload or experiment. All applicants must meet specific physical requirements and must pass NASA space physical examinations with varying standards depending on classification.

1.1.2 Flight Controllers

Flight control teams consisting of Space Shuttle systems experts staff the Flight Control Room (FCR) consoles in the Mission Control Center (MCC) during missions. The primary objectives of the Space Shuttle flight control team are to closely monitor and direct the crew during critical mission phases, to provide support in conducting the mission, and to extend the system analysis capability of the crew by providing systems expertise support on the ground.

Flight controllers who work in the FCR represent only part of the shuttle mission staffing in the MCC. Each of the flight controllers sitting at a console in the FCR has the help of other engineers and flight controllers monitoring and analyzing data in nearby staff support rooms.

There are 19 mission controller consoles in the FCR. Under the direction of the Flight Director, a systems specialist certified in vehicle systems, operations, or flight dynamics operates these consoles. Every position has a "call sign," the name the controller uses when talking to other controllers over the communications loops. Some FCR positions may not be staffed for each mission depending on the flight phase and the requirements of the flight.

1.1.3 Launch Controllers

The Launch Control Center (LCC) at the Kennedy Space Center oversees all aspects of Space Shuttle launch operations. Launch controllers specializing in Space Shuttle systems, test procedures, and launch countdown procedures staff consoles for every launch. There are 17 consoles in Firing Room. Several systems engineers staff each console.

Launch controllers who work in the control room represent only part of the shuttle launch staffing in the LCC. They have the help of other engineers and launch controllers in nearby support rooms.

Under the guidance of the launch director, they oversee the countdown for a shuttle launch beginning at launch minus three (L-3) days through liftoff and tower clear when the MCC in Houston assumes responsibility for vehicle and crew. Each launch controller has a "call sign" that is used when talking to other controllers over the communications loops.

1.2 Training Facilities

1.2.1 Johnson Space Center (JSC)

The Johnson Space Center in Houston, Texas, is the primary training center for NASA's human space flight programs. The majority of training for Space Shuttle missions takes place in facilities in and around the JSC.

Each facility is used to train specific aspects of a shuttle mission. A description of some of the key Space Shuttle training facilities at or nearby the JSC are listed below:

Single System Trainers (SST) – Three SSTs are located in Building 4S. They are used to conduct part-task training in a high-fidelity mockup of the Orbiter flight deck. Classes are instructor led, typically with one or two students. Lessons focus on either nominal operations or malfunction recovery in one Orbiter system.

Shuttle Mission Simulator (SMS) – The SMS is located in Building 5. There are 3 training simulators, 1 motion-base and 2 fixed-base. These are full-fidelity simulators used to provide mission rehearsal in ascent, orbit and entry operations. Simulations can be run "stand-alone", meaning just the crew and instructors – or "integrated" during a simulation combined with the mission control team. The focus of integrated training is on team interaction.

SPACEHAB Volumetric Trainer (SVT) – The SVT is located in Building 5. It is a mockup of the SPACEHAB and its components. This is a low-fidelity trainer used to teach basic SPACEHAB module layout. In some simulations, the SVT is used in conjunction with one of the fixed-base simulators.

Space Vehicle Mockup Facility (SVMF) – The SVMF is located in Building 9. Several high fidelity Orbiter mockups are used to train crew ingress, egress, mission timelines, crew habitability, photo/TV courses, onboard equipment stowage and airlock operations.

Neutral Buoyancy Lab (NBL) – The NBL is located at a facility near JSC. It is a large pool used for Extra Vehicular Activity (EVA) training, EVA tool and procedures verification and extra- and intra-vehicular crewmember coordination. It is also used for bailout training.

Mission Control Center (MCC) – The MCC is located in Building 30S. While it is the nerve center for actual mission operations, it is used to conduct integrated simulations with crewmembers in the SMS. The MCC is critical to training the "team" of crew and mission controllers for a specific mission.

Flight Controller Trainer (FCT) - The FCT is located in Building 4S. It is used to conduct part-task training with flight controllers using a hi-fidelity mockup of a flight

controller console. Classes are instructor led, typically with one or two students. Lessons focus on either nominal operations or malfunction signature recognition for orbiter systems.

Shuttle Training Aircraft (STA) - The STA is a modified Gulfstream II business jet used for training the approach and landing phase of a shuttle mission. The left side of the cockpit is modified to simulate the Orbiter flight deck. It has a rotational hand controller and computer displays that are identical to the Orbiter. The pilot and commander fly approaches to runaway under guidance of an instructor pilot.

1.2.2 Other Training Facilities

Training on crew equipment interfaces, launch terminal countdown, launch pad aborts, and emergency egress training is held with each mission crew at the Kennedy Space Center (KSC). This training is conducted using the actual vehicle, flight hardware and the launch pad facilities. Launch team training is conducted in dedicated computer facilities and also in the actual launch firing rooms in the Launch Control Center.

Depending on the unique payload or flight requirements of each shuttle mission, training can be accomplished at other NASA centers, various international space agency facilities, commercial industry facilities or academic/scientific research facilities.

1.3 Space Shuttle Training Process

1.3.1 Basic Training and Certification

Each operator begins with a phase of Space Shuttle basic training before embarking on detailed training designed to the specifics of his or her job. This comprehensive training includes: immersion in the study of shuttle systems, shuttle flight mechanics, shuttle flight dynamics, mission operations, workbooks, computer-based training lessons, classroom lectures, part-task training classes, hands-on training with vehicle hardware, on-the-job training with mentors and participation in shuttle simulations.

Satisfactory completion of the training certification flow indicates that an operator is eligible to hold a specific position during a Space Shuttle mission and results in a certification for the operator. Obtaining certification for a particular mission position signifies that person is eligible for assignment during a Space Shuttle mission.

After certification, the person enters a period of maintaining proficiency in their knowledge/skill level and participating in periodic training sessions while awaiting flight assignment. The average time required to move from basic training to actual mission flight assignment is four to five years for crewmembers and one to two years for controllers.

The Mission Operations Directorate (MOD) at the JSC is responsible for providing the training and certification for flight crews, mission controllers, and the instructors who train them. Space Shuttle training requirements for the crew are documented in the Crew Training Catalog (CTC). For flight controllers, the training certification process is documented in the "Mission Operations Directorate Space Flight Personnel Certification Plan". For launch controllers, the training certification process is documented in the "KSC Launch Team Certification Plan."

Space Shuttle Program (SSP) training is a Contractor Accountable Function (CAF). The prime contractor responsible for SSP training is the United Space Alliance (USA) under the Space Flight Operations Contract (SFOC).

1.3.2 Mission Specific Training

Mission Specific training consists of: qualification, flight similar, proficiency and flight specific.

Qualifications

Upon flight assignment, each operator begins learning the specifics of the mission. For flight crewmembers, training begins nine months to one year prior to the scheduled launch date depending on the complexity of the mission objectives. The controllers assigned to the mission join the crew in training about three to four months prior to launch. The major reason for the controllers joining the crew late in the training flow is the fact that controllers work multiple missions with more frequency where crewmembers are assigned one a mission at a time and years may have passed since their last mission. Controllers maintain their knowledge-skill level by supporting more missions with more frequency than crewmembers and do not require the extensive mission specific training required by the crewmembers.

A team of instructors is assigned to work with the crewmembers for the duration of their training to provide continuity and consistency. Mission training begins with the crewmembers passing a series of qualifications, or "quals" which may consist of oral examinations or training sessions in a single system trainer requiring the crewmember to demonstrate operational knowledge of a particular shuttle system. These "quals" demonstrate that crewmembers have the expected proficiency in Space Shuttle systems and are ready to begin detailed mission training.

Flight Similar

After meeting qualification requirements, the crew begins "flight similar" training. Flight similar training uses flight products such as Orbiter software and crew procedures that are similar to those they will have for their mission. Mission specific flight products are not usually released until 3 to 4 months prior to launch due to development, testing and verification. Flight similar training offers a standard set of lesson scenarios in crew resource management, ascent, orbit, entry, and other specialized topics. During these lessons, the crew practices working together as a team, performing those tasks they are responsible for during various phases of the mission and responding to anomalous situations that may occur during these mission phases. Early payload training takes place during this time period as well.

Proficiency

If the crew completes all lessons in the flight similar standard set before their flight products are ready for use, they enter a period of "proficiency" training. Proficiency training is scheduled several times a week. By design, it is intended to maintain or advance the crew knowledge or skill level achieved during flight similar training. The proficiency phase can also be entered if there is an extended launch slip.

Flight Specific

After flight products delivery, the crew enters the final phase of mission training called "flight-specific" training. Flight-specific training focuses on rehearsing all aspects of the mission using the actual Orbiter flight software and procedures for that mission. During this period the mission control teams assigned to the mission join the crew for integrated simulations. This integrated training allows the crew and the flight control team to rehearse all aspects of the mission and its major objectives using the flight products they will use during the mission. During flight-specific training, the crew also performs a launch countdown test with launch controllers at the KSC and participates in more detailed payload training. Flight-specific training continues until one week prior to launch when the crew enters quarantine. If there are extended launch slips during this phase of training, the crew and flight controllers may re-enter the proficiency phase.

2.0 STS-107 Training Factual Information

2.1 Crew Training

Seven crewmembers were to be assigned to the STS-107 mission, tentatively scheduled for launch on January 11, 2001. However, the payload specialist and mission specialists were not assigned until July 26, 2000, signaling that the mission launch date would slip. The official press release announcing these assignments ultimately came on September 28, 2000.

The commander and pilot were assigned on October 27, 2000. The official press release announcing these assignments came on December 1, 2000.

The flight assignments were:

Commander:
Rick D. Husband, Colonel, USAF
Pilot:
William C. McCool, Commander, USN
Mission Specialist 1/EV1:
David M. Brown, M.D, Captain, USN
Mission Specialist 2:
Kalpana Chawla, Ph.D
Mission Specialist 3/Payload Cdr/EV2:
Michael P. Anderson, Lieutenant Colonel, USAF
Mission Specialist 4/IV:
Laurel Blair Salton Clark, M.D., Captain, USN
Mission Specialist 5:
Ilan Ramon, Colonel, Israeli Air Force

Commander Husband flew as pilot on STS-96. Mission Specialist Chawla flew on STS-87. Mission Specialist Anderson flew on STS-89.

STS-107 was the first mission for Pilot McCool, Mission Specialists Brown and Clark, and Payload Specialist Ramon.

The primary mission objective of STS-107 was to conduct a variety of science experiments carried in the SPACEHAB Research Double Module (RDM) or on the Orbiter middeck. A secondary mission objective was the operation of the Fast Reaction Experiment Enabling Science, Technology, Applications and Research (FREESTAR) located in the aft payload bay of *Columbia*.

The STS-107 payload crew began training for the mission on August 14, 2000, working toward a June 14, 2001, launch date. For the first few months of training, the crew completed their qualification training, took systems refresher classes, participated in SPACEHAB and mission experiment familiarization, and traveled to see SPACEHAB hardware at the KSC. The commander and pilot joined the crew in training on November 1, 2000.

On November 9, 2000, the launch date was moved to August 2, 2001, delaying the planned start of flight similar training.

Flight similar training began on January 3, 2001. In the following weeks the crew participated in simulator sessions, suited ingress and egress training and attended several payload experiment hands-on training sessions.

On February 13, 2001, the launch date was slipped to October 25, 2001. The crew continued work on the flight similar training requirements.

On March 15, 2001, the launch date was slipped to April 4, 2002 when the STS-109 Hubble servicing mission, which was scheduled to fly on *Columbia*, was assigned a higher priority. The crew continued work on flight similar training requirements and traveled to the European Space Agency (ESA) for hands-on training of ESA-sponsored payload experiments on STS-107. While in Europe for this training, the launch date was slipped to May 23, 2002. The crew completed their flight similar training requirements on July 3, 2001.

After a two-week vacation, the crew began flight specific training the week of July 23, 2001. They participated in mission specific training sessions and traveled to various payload customer facilities for hands-on training for STS-107 experiments.

On October 25, 2001, the launch date was slipped to June 27, 2002. By this date, the crew had been in training for over a year.

The crew entered proficiency training mode due to the extended launch slip. They also traveled to Florida for SPACEHAB timeline training in the SPACEHAB Research Double Module.

On January 24, 2002, the launch date was slipped to July 11, 2002.

On February 5, 2002, the crew resumed flight specific training and continued in-depth payload experiment training including a trip to Goddard Space Flight Center (GFSC) for training on the FREESTAR payload.

On April 11, 2002, the launch date was slipped to July 19, 2002.

Flight specific integrated orbit training, including Joint Integrated Simulations (JIS) with the payload customers, the crew and the orbit flight control teams began on April 23, 2002. Over the next few months, five STS-107 mission JISs were conducted to exercise SPACEHAB activation, deactivation, and experiment portions of the mission timeline.

Integrated ascent and entry training with the crew and ascent/entry flight control team began on May 6, 2002.

On June 8, 2002, the crew traveled to the KSC for the Crew Equipment Interface Test (CEIT). When they returned they continued integrated training with the flight control teams.

On July 22, 2002 and July 31, 2002, two launch slips occurred, to September 26, 2002 and November 29, 2002 respectively.

The crew entered proficiency training mode and remained in that mode for the next month and a half. On September 12, 2002, the launch slipped for a final time to January 16, 2003. The crew had been in training for over two years.

In the final four months of training, the crew traveled to Europe once more for payload experiment training. They repeated ascent and entry integrated training with the flight control team. An additional orbit JIS was added for the orbit flight control team since the last JIS had taken place almost six months prior.

On December 17, 2002, the crew traveled to KSC for the Terminal Countdown Demonstration Test (TCDT), a launch day "dress rehearsal" with the launch control team.

STS-107 mission training was completed on January 9, 2003, with the final ascent integrated simulation with the mission control team. The crew entered quarantine that afternoon. They departed Houston for the Kennedy Space Center on January 11, 2003.

All Space Shuttle mission training requirements defined in the Crew Training Catalog and listed in the Crew Training Plan were completed. Multiple launch slips allowed for additional training to be added or training sessions to be repeated to maintain or enhance crew flight proficiency. According to Space Flight Training Division training records, the cumulative Space Shuttle mission training for the STS-107 crewmembers was 4,811 hours.

Individual crewmember training hours for STS-107 were:

Crewmember	Hours
Husband	822
McCool	830
Brown	766
Chawla	876
Anderson	441
Clark	638
Ramon	437

SPACEHAB, Inc. recorded 3,506.6 hours crew payload experiment training. Fifteen weeks of this payload and experiment training were conducted at payload sponsor facilities at Marshall Space Flight Center, SPACEHAB facilities in Florida, Goddard Space Flight Center, Glenn Research Center and European Space Agency (ESA) facilities.

Experiment training for STS-107 consisted of at least one familiarization briefing for each experiment and one or more hands-ons training sessions with experiment hardware. SPACEHAB subsystem training consisted of familiarization training, part task training, in-flight maintenance training, SPACEHAB activation and deactivation training, and SPACEHAB procedure reviews.

While the STS-107 crew was in training, the launch date slipped a total of 10 times, plus three times prior to the crew being selected. The STS-107 crew never stopped training and maintained their proficiency until launch. By launch time, they had completed 126 weeks of training, about 74 weeks longer than the average duration of Shuttle mission training.

2.2 Flight Controller Training

There were five teams of mission controllers assigned to STS-107: an ascent and entry team, and four orbit teams to support around the clock operations of the dual shift mission.

The Ascent/Entry flight control team began training with the STS-107 crew on October 22, 2002 participating in a total of 16 integrated ascent or entry simulations with the STS-107 crew. Due to the launch slips, training requirements forced some of these simulations to be repeated. The ascent/entry simulations for STS-107 were held on the dates listed below. The repeated simulations are indicated.

Ascent #1	April 22, 2002
Entry # 1	May 6, 2002
Deorbit Prep	May 23, 2002
Ascent #2	May 28, 2002
Ascent #3	June 24, 2002
FDO/BSE	June 14, 2002
Ascent #1(repeated)	October 22, 2002
Entry # 1 (repeated)	October 24, 2002
Ascent # 2 (repeated)	November 8, 2002
FDO/BSE (repeated)	November 19, 2002
Entry #2	December 9, 2002
Deorbit Prep(repeated)	December 13, 2002
Post Insertion	December 16, 2002
Ascent #3 (repeated)	January 3, 2003
Entry # 3	January 7, 2003
Ascent # 4	January 9, 2003

The Orbit flight control team began training with the STS-107 crew on April 23, 2002, participating in a total of six joint integrated simulations with the STS-107 crew and payload customers. Due to the launch slips, one 30-hour JIS was added since the previous JISs has been run almost six months prior. The JISs were held on the dates listed below:

(NOTE: the JIS numbers indicate the name of the JIS and do not imply a numerical order in which they should have been accomplished.)

JIS # 1 – 8 hours	April 23, 2002
JIS # 3 – 17 hours	May 3, 2002
JIS # 4 – 12 hours	May 15, 2002
JIS # 2 – 16 hours	June 21, 2003
JIS # 5 – 10 hours	June 25, 2002
JIS # 6 – 30 hours (added)	December 10, 11, 2002

There were 77 FCR operators assigned to four shifts during the STS-107 mission. All had initial certifications and had worked missions in the past. Seven failed to complete re-certification requirements prior to the STS-107 launch, and by MOD standards, were not re-certified at the time of the mission. Flight controllers are required to re-certify for their positions periodically. For most positions the re-certification requirement is every 18 months. The Board did not consider this paperwork oversight to be a contributing cause to the accident, but believes that the Space Shuttle Program should be more aware of these situations and prevent any reoccurances.

2.3 Launch Controller Training

The STS-107 Launch Control Team participated in the Terminal Countdown Demonstration Test (TCDT) with the STS-107 crew on December 20, 2002. The TCDT was a full "dress rehearsal" of the launch day countdown activities from crew suit-up, walkout, transport to the pad, crew ingress into the Orbiter and terminal launch countdown. The test ended with a simulated anomaly forcing the team and crew to declare a pad abort and emergency pad egress.

All launch controllers were certified to staff their launch control positions for the TCDT and the day of launch.

2.4 Readiness Reviews/Certificate of Flight Readiness (CoFR)

The STS-107 Launch Readiness Review (LRR) was held on December 18, 2002 at the KSC. There were no training issues for launch controllers indicated from either NASA or USA.

For the STS-107 Flight Readiness Review (FRR) held on January 9, 2003, the Mission Operations Directorate (MOD) listed no issues for crew or flight controller training. According to FRR documentation, all personnel were trained and certified or would be trained and certified prior to the flight. This statement was erroneous given the previously-mentioned seven flight controllers assigned to the mission did not have current re-certifications at the time of the FRR, nor were they re-certified by the mission date. This contradicts the MOD Shuttle Certificate of Flight Readiness (CoFR) signed by NASA and USA managers on December 18, 2002.

3.0 Training Investigation and Assessment

STS-107 training requirements for the crew and controllers were reviewed then compared against training records to verify that all required training was completed. The outcome of that training was studied to assess training readiness and identify areas of deficiency in crew or controller performance.

3.1 Crew

A review of documentation outlining STS-107 crew training requirements was conducted. The documentation included the Crew Training Catalog, Crew Training Plan, Assigned Crew Study Guide, Crew Task Assignments, SPACEHAB Mission Specific Training Plan, and Integrated Simulation Plan associated with STS-107. All requirements outlined in the Crew Training Catalog were listed in the STS-107 Crew Training Plan as training objectives to be achieved during the course of training.

Crew training records and weekly crew activity schedules indicated that the prescribed prerequisite flow as outlined in the Crew Training Catalog was strictly followed. Due to launch slips, the appropriate proficiency training lessons were scheduled and training was repeated, if required.

All training requirements were for the STS-107 crew were completed. The crew completed more training than required because of the numerous launch slips.

Interviews, discussions, and a comprehensive review of written instructor training logs and simulation observations notes were conducted to better understand the crew's performance during training and their ultimate readiness for flight. An interview with the STS-107 Training Team Lead revealed no issues with crew performance and described the crew as "more than ready" for flight. Discussions with Training Division management regarding periodic meetings held with Commander Husband indicated that he expressed confidence in his crew's performance and had no problems with the quality of the training the crew received. Independent simulation observations completed monthly by senior training personnel indicated no concerns with crew performance. Individual instructor notes written during crew training sessions show the crew progressed steadily as expected in their knowledge level and readiness, peaking just prior to launch. The training flow was remarkable in length only.

The analysis of training information supports the finding that crew training requirements for STS-107 were complete and the crew was adequately trained for their mission tasks.

3.2 Flight Controllers

A review of documentation for STS-107 flight controller training requirements was conducted. This documentation included the MOD Space Flight Personnel Certification

Plan, flight controller training certification records, and the STS-107 Integrated Simulation Plan.

Training records indicated that flight controllers were qualified to work their respective positions for STS-107. However, seven did not have current certification paperwork in their training folders. Discussions with flight control management for the seven indicated that they had not completed the requisite proficiency re-certification requirements prior to STS-107. Possible explanations offered by managers as to why these certifications were deficient were attributed to smaller numbers of personnel in these groups. This investigation did not identify the reason for the smaller numbers of personnel nor the impact on this issue.

All STS-107 mission specific training requirements for flight controllers were complete. Integrated simulations were repeated to maintain team proficiency as required due to launch slips.

The flight controller performance during training and their readiness for flight, detailed interviews, and a comprehensive review of written instructor training logs and simulation observations were conducted. Interviews with the ascent, orbit, and entry Simulation Supervisors suggest no issue with any of the flight control teams' performance prior to the mission. Instructor written logs and independent simulation observations indicate no performance issues with any flight control team members or teams.

The analysis of training information supports the finding that the STS-107 flight controller training requirements for STS-107 were complete and they were adequately trained for their mission tasks. The board does not believe the recertification issue to be significant in regards to this accident. That said, the Board is somewhat concerned that the absence of re-certification in this instance may be an indication of decreasing standards and management oversight of important training and certification processes.

While reviewing mission control personnel training, it was discovered that Mission Management Team (MMT) simulations are held. There have been six such simulations to date. They were conducted every 18 months.

While these simulations are positive, they were lacking in scope and frequency. All MMT simulations dealt only with ascent abort scenarios that resulted in intact aborts and landings. They were all held at KSC and all participants were briefed that the scenario would be an launch contingency. By stating in advance that this simulation would result in a launch contingency it possibly biased the participants and allowed them to think ahead as to what their reactions would be for just a handful of contingency scenarios. Members of Space Flight Training Division were participants in the last simulation held, but seemed to be in a passive, observation role, rather than actively planning the scenarios and evaluating the performance of the participants.

The MMT would benefit from more frequent simulations with scenarios that include ascent, orbit, and entry problems. Simulations should be conducted at JSC as well. Since the MMT resides in Houston during on-orbit operations, JSC simulations would be beneficial with respect to in-flight crises that require MMT intervention. Space Flight Training Division personnel should be responsible for the planning and execution of the simulations in the future as they are for crew and mission controller training.

3.3 Launch Controllers

A review of documentation outlining STS-107 launch controller training requirements was conducted. This documentation included the Launch Personnel Certification Plan, launch controller training certification records, and the STS-107 Terminal Countdown Demonstration Test (TCDT) training plan and post-TCDT report.

Training records indicate that the launch controllers were certified to work their respective positions for STS-107. All STS-107 training requirements for launch controllers were complete. TCDT documentation and post-TCDT report shows no issues with launch control team performance.

The analysis of training information supports the finding that the STS-107 launch controller training requirements for STS-107 were complete and they were adequately trained for their mission tasks.

3.4 Mission Performance

Since the majority of the STS-107 mission was completed prior to the loss of the vehicle, actual crew, launch controller, and flight controller readiness for flight can be surmised from how they performed their STS-107 mission duties. Launch countdown documentation, mission console logs, and Mission Control Center data were reviewed.

All operators of STS-107 performed satisfactorily during the launch countdown, launch, and subsequent flight. There were a few incorrect switch movements by the crew during the mission, including the configuration of an inter-communications switch and an accidental bump of a rotational hand controller (which affected the Orbiter's attitude) after the de-orbit burn but prior to Entry Interface. The inter-communications switch error was identified and then corrected by the crew; both the crew and Mission Control noticed the bump and took the necessary steps to place the Orbiter in the correct attitude. Neither of these events was a factor in the accident, nor are they considered training or performance issues.

Crew and mission controller actions were unremarkable prior to the loss of vehicle and crew. All actions were in accordance with entry procedures. A review of mission control data supports the finding that there were no crew or mission controller performance issues during the mission or in the moments leading up to loss of signal.

Following the loss of signal and unsuccessful attempts to contact the STS-107 crew, the Entry Flight Director declared a Space Shuttle contingency and implemented the JSC Contingency Plan documented in the Flight Control Operations Handbook.

4.0 Findings

1. Crew and controllers training requirements for STS-107 were completed and the all were adequately trained for their mission tasks.

2. Training records indicated flight controllers were qualified to work their respective positions for STS-107, but seven did not have current re-certification paperwork in their training folders. This contradicts the MOD CoFR and FRR documentation indicating personnel were trained and certified or would be trained and certified prior to the flight.

3. There were no crew or mission controller performance issues during the mission or in the moments leading up to loss of signal.

5.0 Conclusions

1. Crew training was not a factor in the loss of *Columbia* and the STS-107 crew.

2. Mission controller and launch controller training were not factors in the loss of *Columbia* and the STS-107 crew.

6.0 Observations

1. A thorough review of all mission controller certification records should be completed prior to a mission. This should be done early enough to allow time for those lacking current certifications to complete the requirements for them, or to allow replacement by a flight controller with a current certification.

2. Management should ensure the accuracy of the data represented at the Flight Readiness Review and before signing the Certificate of Flight Readiness.

3. Management should examine the flight control organization for causes or factors that might have resulted in several flight controllers not having current re-certifications while working a mission.

4. MOD should conduct MMT simulations with more frequency. These should include ascent, orbit, and entry scenarios. Simulations should be conducted at JSC and KSC. JSC simulations are beneficial with respect to in-flight issues that require MMT intervention. Space Flight Training Division personnel should be responsible for the planning and execution of the simulations as they are for crew and mission controller training.