# Operations Panel
# Fact-Finding Status

**Col. James Adamson, Lead**

# Operations Panel
# CAIB Recommendations

**3.4-1 Ground-Based Imagery**

**3.4-2 High-Resolution Imagery of External Tank (ET)**

**3.4-3 High-Resolution Imagery of Orbiter**

**4.2-5 KSC Foreign Object Debris (FOD)**

**10.3-1 Digitize Close Out Imagery**

**SSP-3 Contingency Shuttle Crew Support (CSCS)**

# Operations Panel Acceptance Recommendations

1. R3.4-1 Ground-Based Imagery – Mr. Robert Sieck
2. R3.4-2 High-Resolution Imagery of External Tank (ET) – Lt. Gen. Forrest McCartney
3. R4.2-5 KSC Foreign Object Debris – Lt. Gen. Forrest McCartney
4. R10.3-1 Orbiter Digitize Closeout Photography – Mr. Robert Sieck

# Operations Panel

## R3.4-1 Ground-Based Imagery

## Mr. Robert Sieck

# 3.4-1 Ground-Based Imagery

## CAIB Recommendation

Upgrade the imaging system to be capable of providing a minimum of three useful views of the Space Shuttle from liftoff to at least Solid Rocket Booster separation, along any expected ascent azimuth. The operational status of these assets should be included in the Launch Commit Criteria for future launches. Consider using ships or aircraft to provide additional views of the Shuttle during ascent.

# 3.4-1 Ground-Based Imagery

**RTF TG Interpretation**

- The CAIB made the following finding:
  - F3.4-4 *The current long-range camera assets on the Kennedy Space Center and the Eastern Range do not provide best possible engineering data during Space Shuttle ascents.*
- CAIB image analysis was hampered by the lack of high-resolution and high-speed ground-based cameras.
- Existing camera locations were a legacy of earlier NASA programs, and were not optimum for the exit trajectory of Space Shuttle missions.
- Due to equipment problems, camera film was not always usable
- The CAIB suggested that NASA treat the vehicle as developmental and therefore collect as much technical information as practical, specifically to provide photographic coverage from more than one view of the Space Shuttle during the launch trajectory through separation of the Solid Rocket Booster (SRB).

# 3.4-1 Ground-Based Imagery

## NASA Implementation

- Maximize the ability to capture three complementary, useful views of the Shuttle
  - Short, Medium, and Long-range tracking devices will be added using a combination of mobile and fixed tracker mounts to optimize mission-specific images
  - Approach is to obtain the best coverage of entire vehicle from T-0 through SRB separation
  - Airborne assets are being developed to supplement ground capability

# 3.4-1 Ground-Based Imagery

## Implementation Limitations

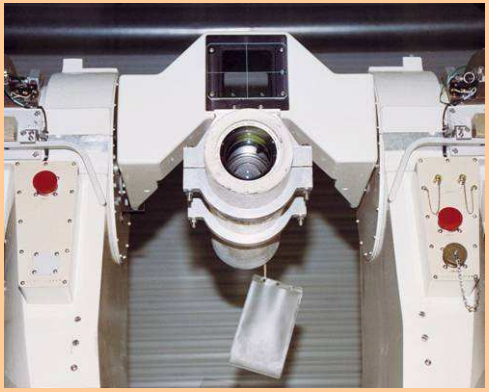
- While the ground/airborne cameras provide important engineering data for the Shuttle
  - Resolution will not definitively establish that the Orbiter has not suffered any ascent debris damage.
  - No real-time decisions will be based on ground imagery data
  - While there is redundancy in the overall approach to collecting ground imagery, the system is categorized as Criticality 3
  - Comprehensive assessments of Orbiter impacts and damage necessary to ensure safety of vehicle and crew will be conducted using on-orbit inspection and analysis
- The integrated imagery analysis is not included as part of this recommendation, but will addressed as part of 6.4-1

# 3.4-1 Ground-Based Imagery

## Tracker Options

IFLOT- Manned Tracker Only; RTF

KTM- Standard configuration showing locations for seat and bat wings; RTF/Post RTF



KTM- Modified with video camera for remote control; Post RTF

KTM- Modified for center mount long lens installation; Post RTF

# 3.4-1 Ground-Based Imagery

## Tracker Options

MOTS: Remotely controlled from VABR; New Tracker proposed

DOAMS: 400 inch primary telescope for film;

200 inch telescope for video

AF asset


ATOTS: Mobile Tracking facility operated by AF for Range Safety

# 3.4-1 Ground-Based Imagery

## WB-57 Ascent Video Experiment

## Airborne Imagery

- NASA has approved the development and implementation of an aircraft-based imaging system
  - Provides both ascent and entry imagery.
  - Combination of 35mm film, HDTV and other imagery available
  - Airborne imaging system will provide opportunities to better observe the vehicle during days of heavier cloud cover and in areas obscured from ground cameras by the exhaust plume following launch

# 3.4-1 Ground-Based Imagery

## Pre-Launch Requirements

- Ground camera status will be assessed prior to ET tanking
- Specific imagery asset requirements will be identified at T-20 minutes for cameras using prime and HDTV fallback :
  - A minimum of three North/South/West Medium Range sites are required (as long as no two are on same tracker)
  - A minimum of three North/South Long Range Sites are required (as long as no two are on same tracker)
  - One airborne asset is required (if cloud cover is an issue)
- Ground camera power - Photo Optic Control Systems (POCS), one of two redundant systems required at T–9 minutes
- Minimum assets to be included in standard launch count requirements documents (Operations and Maintenance Requirements and Specifications Document (OMRSD) and Launch Commit Criteria (LCC))

# 3.4-1 Ground-Based Imagery

## Panel Assessment

- Conducted fact-finding trips at KSC
- Significant progress has been achieved toward coordinating an integrated suite of ground cameras to capture images of the shuttle during ascent
- NASA has significantly increased the number and capability of ground camera sites
- While the total number of camera sites available at launch is TBD, the requirements should ensure an adequate number to meet the CAIB intent for three useful views
- Requirements are still being updated, hardware is being assembled, and procedures are being developed to accomplish the plan

# 3.4-1 Ground-Based Imagery

## Planned Work

- Completion of safety documentation
- Completion of system verification and testing (March 05)
- Completion of training operators of camera mounts (March 05)
- Completion of incorporation of Ground Imagery Project Summary into overall Design Certification Review (April 05)
- Completion of Critical Design Review RID closeout (April 05)
- Standard Readiness Review process (April/May 05)

# 3.4-1 Ground-Based Imagery

## Request For Information (RFI) Closure

- To accomplish closure of open RFI's (Ops-070/Ops-071), NASA will:
  - Establish program requirements, including the minimum assets required for launch count
  - Specify the participants and organizations responsible for certifying mission capability during launch count
  - Specify the reporting mechanism to launch management for imagery asset status
  - Specify how the usability of imagery assets will be evaluated when weather obstructions exist

# 3.4-1 Ground-Based Imagery

**Recommendation**

- NASA has conditionally met intent of CAIB Recommendation 3.4-1
- RTF TG will review for full closure upon completion of planned work RFI closures

# Operations Panel

## R3.4-2 High-Resolution Imagery of External Tank (ET)

## Lt. Gen. Forrest McCartney

# 3.4-2 High-Resolution Imagery of External Tank (ET)

**CAIB Recommendation**

Provide a capability to obtain and downlink high-resolution images of the External Tank after it separates.

# 3.4-2 High-Resolution Imagery of External Tank (ET)

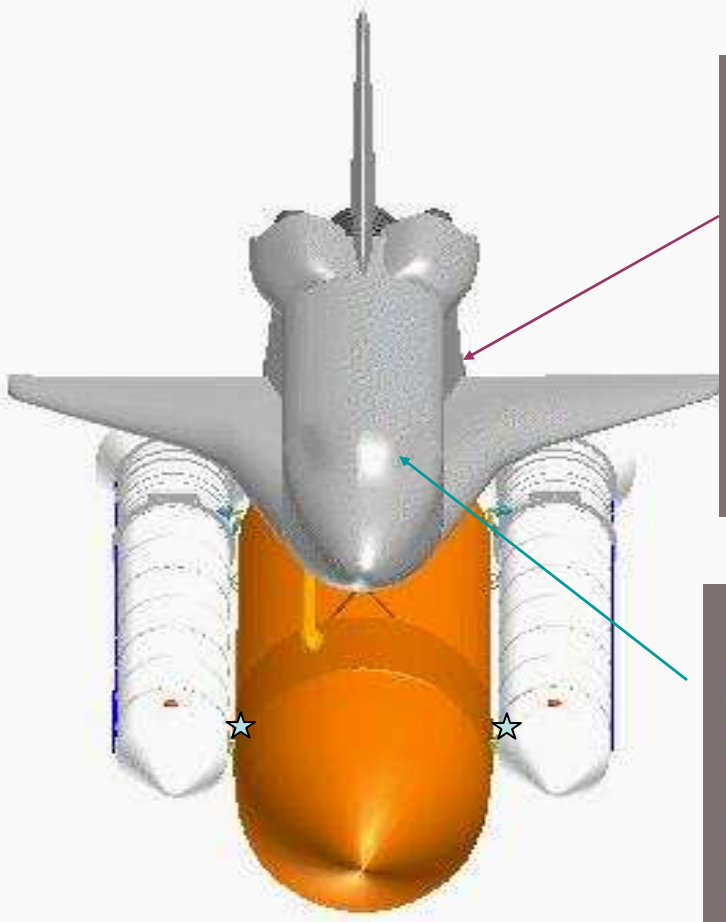
**RTF TG Interpretation**

- Engineering quality imagery of the ET taken from Columbia would have been of great significance in the Columbia investigations.
- The CAIB made the following :
  - F3.4-3 *There is a requirement to obtain and downlink on-board engineering quality imaging from the Shuttle during launch and ascent.*
- Columbia carried the standard on-board film still camera installed in the umbilical well that provides images of the ET following separation from the Orbiter.
  - The camera provides images of sufficient quality/resolution to permit an engineering evaluation of the performance of the ET Thermal Protection System (TPS) to include foam shedding.
- Following ET separation, the Orbiter is maneuvered into a position that permits a crew member to take images, using a hand-held film still camera, of the ET which also provides data regarding foam shedding.
  - Following landing, the film from the umbilical well and hand-held crew cameras is removed and developed for evaluation.
  - Neither of these two cameras were recovered from the Columbia debris.

# 3.4-2 High-Resolution Imagery of External Tank (ET)

- Image ET after separation with two digital cameras, then down-link those images on Flight Day 1 while on-orbit to the image analysis community for review.
  - Digital camera for crew photos of the ET after separation
    - New use for existing digital camera
    - Changed stowage location for easy access for the crew at ET Separation.
    - Modified the Orbiter pitch-over maneuver to occur sooner so the ET is closer to the Orbiter for better images
  - Digital Umbilical Well Still Camera
    - Replacing the 35mm still film camera located in the right Orbiter Umbilical Well with a Digital Still Camera.
    - Re-certify existing digital camera for this use

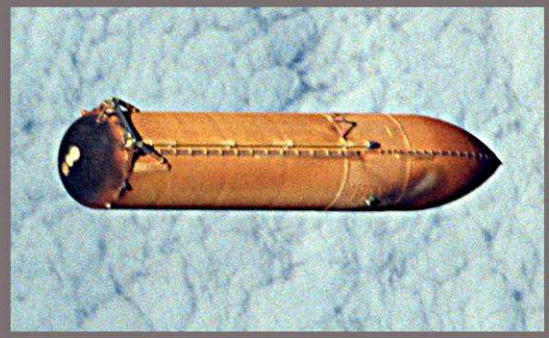
# 3.4-2 High-Resolution Imagery of External Tank (ET)



35mm Umbilical Well Camera Imagery

Frame #5 STS-112

35mm External Tank Handheld Imagery



Frame #11 STS-104

# 3.4-2 High-Resolution Imagery of External Tank (ET)

## Panel Assessment

- Conducted fact-finding at KSC
- Appropriate cameras have been selected
- NASA has accelerated the installation of the digital umbilical well camera to meet STS-114 milestones
- NASA has completed or scheduled all of the remaining work that will allow this additional capability to be flown on STS-114

# 3.4-2 High-Resolution Imagery of External Tank (ET)

## Planned Work and RFI Closure

- Crew Hand-Held Camera
  - None
- Digital Umbilical Well Camera
  - Qualification and Flight Camera Hardware
    - Environments testing (thermal, vibration, etc.) (January 2005)
    - Acceptance testing (February 2005)
    - Test Documentation completion (February 2005)
    - Flight camera installation (March 2005)
  - DCR (February 2005)

# 3.4-2 High-Resolution Imagery of External Tank (ET)

**Recommendation**

- Contingent upon successful completion of scheduled work, NASA has met the intent of CAIB Recommendation 3.4-2

# Operations Panel

## R4.2-5 Foreign Object Debris (FOD)

## Lt. Gen. Forrest McCartney

# 4.2-5 Foreign Object Debris

**CAIB Recommendation**

Kennedy Space Center Quality Assurance and United Space Alliance must return to straightforward, industry-standard definition of 'Foreign Object Debris' and eliminate any alternate or statistically deceptive definitions like "processing debris."

# 4.2-5 Foreign Object Debris

## Closure Conditions

- The condition for full closure of CAIB Recommendation 4.2-5 is:
  - Closure of RFI Ops-081, Foreign Object Debris Processes – Audits and Interviews
    - Provide follow-on actions to correct deficiencies with closure material

# 4.2-5 Foreign Object Debris

**Panel Assessment**

- Recommendation was conditionally closed in July
- Audit completed in October, report generated and corrective actions assigned; RFI Ops-081 has been closed
- NASA has met the intention of CAIB Recommendation 4.2-5

# Operations Panel

## R10.3-1 Digitize Closeout Photography

## Mr. Robert Sieck

# 10.3-1 Digitize Closeout Photography

**CAIB Recommendation**

Develop an interim program of closeout photographs for all critical sub-systems that differ from engineering drawing. Digitize the closeout photograph system so that images are immediately available for on-orbit troubleshooting.

# 10.3-1 Digitize Closeout Photography

**Closure Conditions**

- The conditions for full closure of CAIB Recommendation 10.3-1 are:
  - Demonstrate that the Mission Evaluation Room/Mission Management Team (MMT) staff can access the Shuttle Inventory Management System (SIMS) database in a timely manner during integrated real-time simulations
  - Provide objective evidence of completion of training for current photographers who will be taking closeout and Materials Review Board photographs
  - Provide objective evidence of completion of SIMS Familiarization course and Computer-Based Training development

# 10.3-1 Digitize Closeout Photography

**Panel Assessment**

- Recommendation was conditionally closed in July
- NASA has completed training of current workforce and successfully demonstrated use of the SIMS database during two launch countdown simulations
- NASA has met the intention of CAIB Recommendation 10.3-1

# Operations Panel

## R3.4-3 On-Orbit Imagery

## Lt. Gen. Forrest McCartney

# 3.4-3 On-Orbit Imagery

## CAIB Recommendation

Provide a capability to obtain and downlink high resolution images of the underside of the Orbiter wing leading edge and forward section of both wings' Thermal Protection System.

## NASA Implementation

- Primary method for imaging the Orbiter wings will be via the Orbiter Boom Sensor System (OBSS) which is addressed via CAIB Recommendation 6.4-1
- NASA will also use the ET Camera, located in the Liquid Oxygen (LOX) Feedline Fairing, which views the underside of the Orbiter from the forward ET attach point aft for engineering data on the ascent conditions

# 3.4-3 On-Orbit Imagery

## Panel Status Assessment

- NASA has identified the OBSS as the primary method for acquiring high resolution imagery of the underside of the Orbiter wing leading edge and forward section of both wings' TPS
- NASA has chosen to address the OBSS within the CAIB Recommendation 6.4-1 defining their integrated plan for on-orbit inspection and repair
- Therefore, this recommendation will be considered jointly with R6.4-1

# Operations Panel

## SSP-3 Contingency Shuttle Crew Support

Col. Susan Helms
Dr. Amy Donahue

# SSP-3 Contingency Shuttle Crew Support

## NASA Raise the Bar

NASA will evaluate the feasibility of providing contingency life support on board the International Space Station (ISS) to stranded Shuttle crewmembers until repair or rescue can be effected

## NASA Implementation

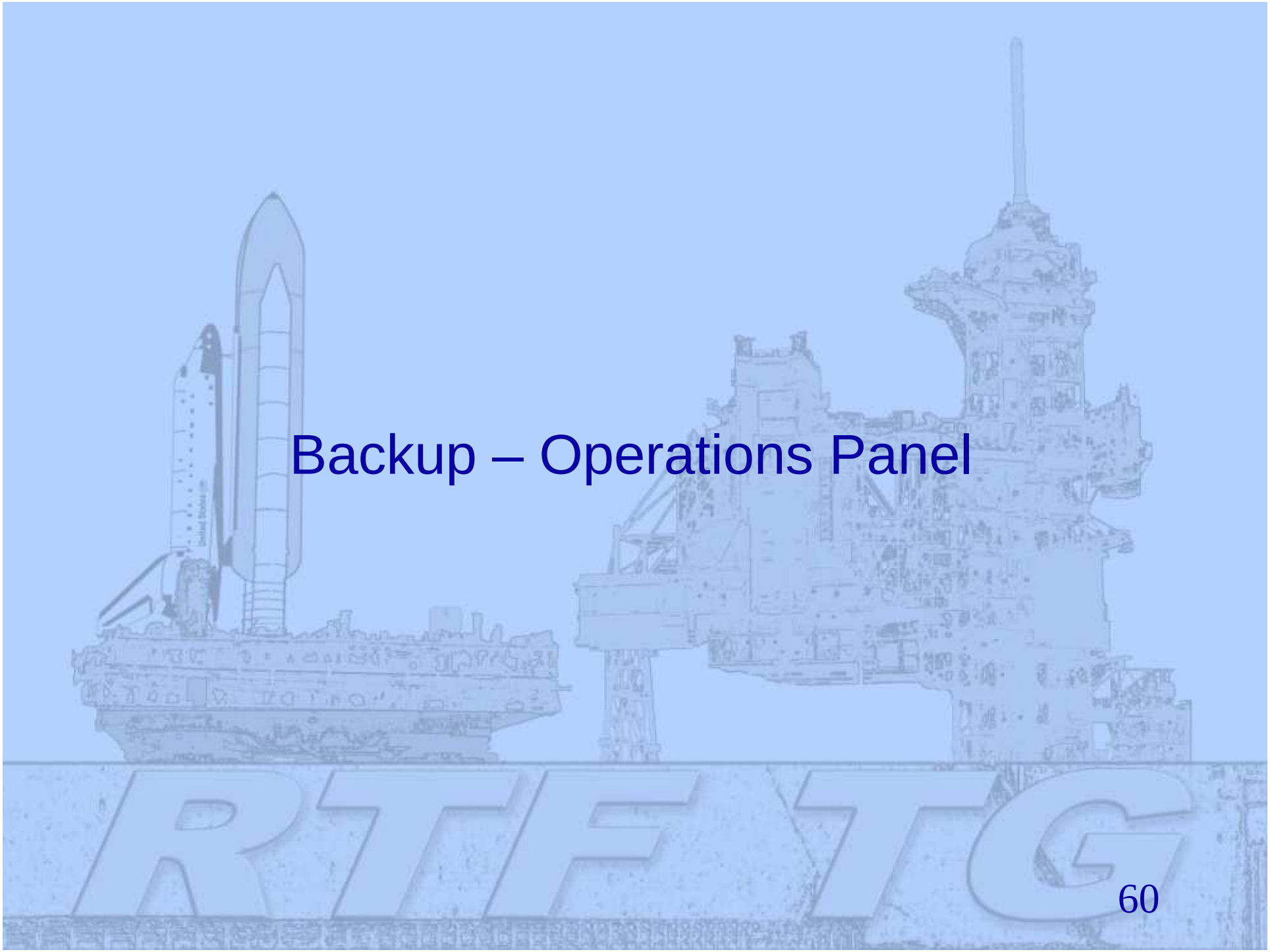
- CSCS will offer a viable emergency capability for crew rescue
- STS-300 Launch On Need (LON) mission planned to provide contingency rescue vehicle requirements
- Developed valid ISS CSCS duration estimation methodology
- For first two flights, no gap exists with the STS-300 rescue capability at Flight Readiness Review (FRR) to provide additional risk mitigation until ET modifications have been validated in flight

# SSP-3 Contingency Shuttle Crew Support

## Panel Status Assessment

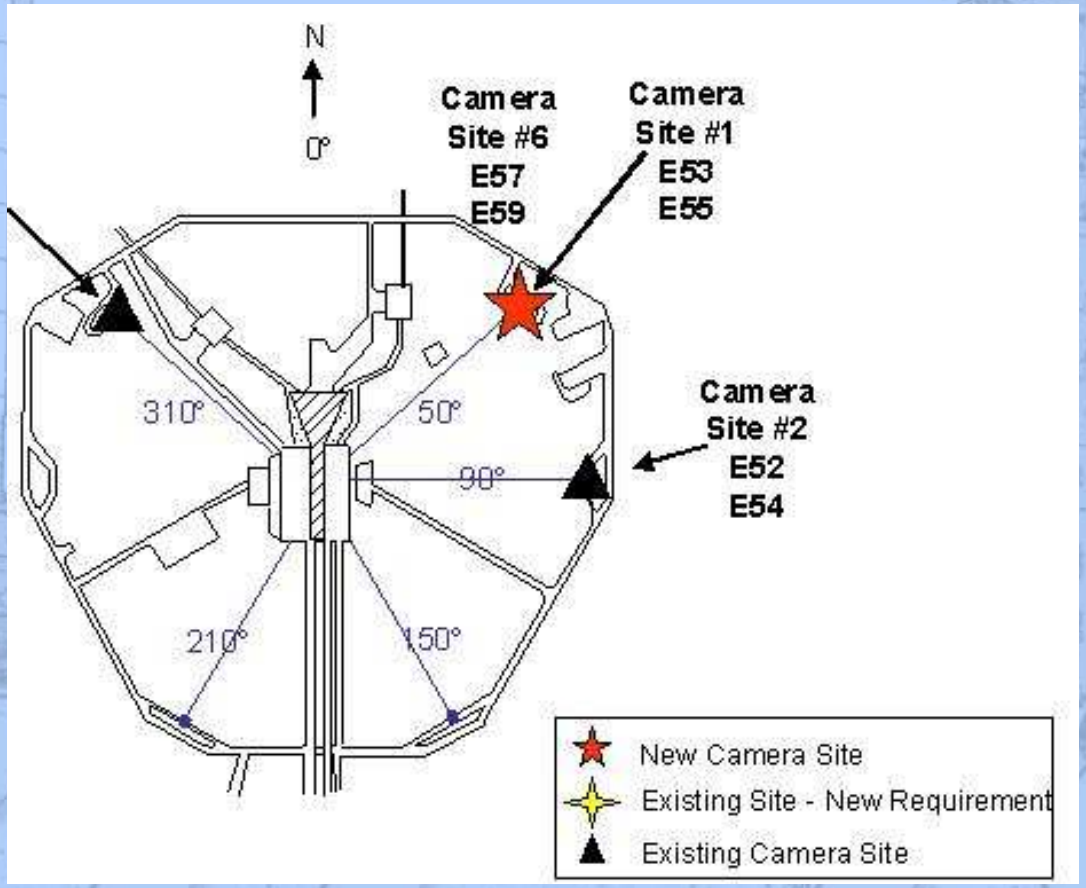
- Robust ISS analysis has been accomplished to demonstrate support for crew rescue, if required
- NASA is making progress addressing nine outstanding (RFIs)
- Integration of CSCS into launch processes and documentation is in progress
- Integration of CSCS into MMT decision-making and simulation is in progress

# Backup – Operations Panel



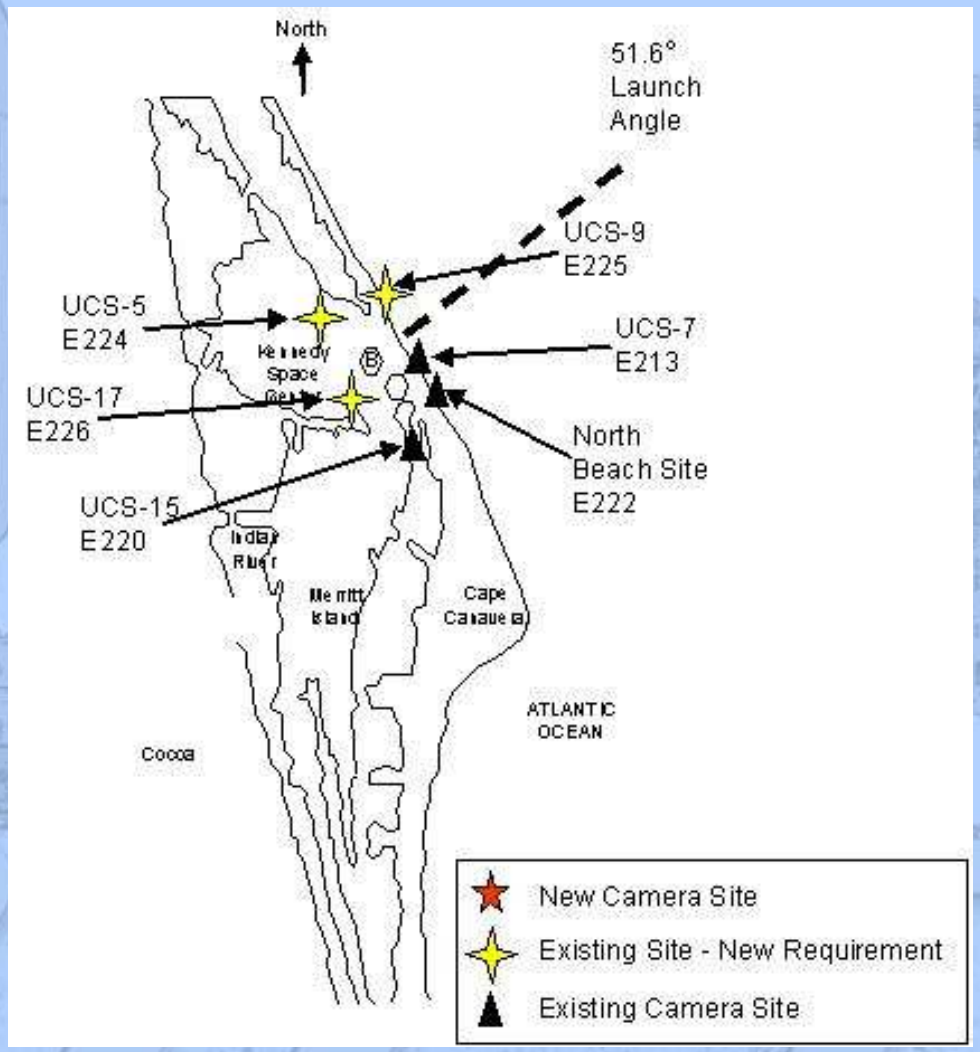
# 3.4-1 Ground-Based Imagery

## Short Range Site Standard Configuration



# 3.4-1 Ground-Based Imagery

## Medium Range Site Standard Configuration



# 3.4-1 Ground-Based Imagery

## Long Range Site Standard Configuration