Questions for Testimony Preparation

Q. How has age of shuttles and shuttle components been monitored, tracked, mitigated and assessed for concerns such as corrosion, wearout, fatigue, obsolesence?

Q. Are there any areas that aren't covered by inspections prior to launch? If so what risk mitigations are in place for these areas?

Q. Are maintenance, inspection and test data kept and trended? Have there been any adverse trends or concerns in these areas?

Q. Have assessments/comparisons been made between telemetry data from the Columbia mission and all other shuttle re-entries?

Q. Were there any process/material/software changes made and implemented prior to this flight (or other recent flights)? How were these qualified/tested/evaluated? Has there been any trend data established that identifies the effectiveness of the changes or weaknesses in the processes/materials/software or resulting systems/equipment?

Q. What independent/external independent control processes were operative? What problems/concerns/changes were implemented based upon these control processes?

Q. Many independent reviews/assessments have been performed at many levels of the Agency and shuttle program have these been reviewed collectively for any trends?

Q. Given the fact that the crew did not have the capability to check tiles through an EVA, was the use of ground and/or satellite imaging considered to check the condition of tiles? If tiles are identified as damaged what options exist or have been considered to respond to the problem?

Q. There are a comprehensive series of reviews that take place prior to launch to determine flight readiness, are there any corresponding reviews performed to determine re-entry and landing readiness? If so, is the level of participation in these reviews the same as for the flight readiness reviews (i.e. the same level of decision makers, the same rigor applied, etc).

Q. Were the roles and responsibilities of Safety and Mission Assurance personnel and organizations clearly defined and understood prior to the mishap?

Q. What mechanism triggers actions taken to correct or improve inherent design weaknesses and improve design/materials/manufacturing?

Q. Were all of the safety recommendations from the Rogers Report and the McDonald report properly addressed/dispositioned/implemented by NASA? Has NASA allowed any subsequent process changes that have eroded previously implemented recommendations?

Q. How are potentially hazardous materials used on the shuttle identified and controlled?

Q. Are there any scenarios for shuttle operations that have not been considered in NASA risk considerations/models/PRA? If so what are they and why haven't they been considered?

Q. What is the pre-launch assessment process used to evaluate and accept shuttles for launch?

Q. What photographic and associated evaluation capabilities exist for launch and re-entry/landing? How are these utilized?

Q. What debris evaluations are conducted for launch/ascent, on-orbit operations, and re-entry landing? How are the results of these evaluations factored into mission decisions.

Q. What records/data are maintained for the condition and configuration of equipment (encompassing everything from tiles to structure, hardware and software)?

Q. Were there any process shortcuts (waivers/deviations) approved for this flight? If so, how are these processed and who approves them?

Q. How are the workers that work on the shuttle program, both Civil Service and Contractor, determined to be qualified to perform their work? What training is provided to these people?

Topical Areas for Safety and Mission Success/Assurance Questions and Answers

Michael: Per your request, we have developed the following list of "topics." These topics are from our SMA Requirements Model. We will use this topical list to organize our Qs and As. We have highlighted topics that we feel definitely need Q&As. Please strike out topics that need not be addressed, and highlight the ones that you believe need the greatest attention.

Policies, procedures, guidelines, and standards

- Policy development
- **Requirements implementation**

Management Leadership & Employee Involvement

- **Management leadership,** commitment, and **involvement**
- Responsibility, accountability, authority, **resources (people, money)**, and **organization**
- Program planning, **schedule, planned upgrades**
- Contractual instruments, **flow-down, insight, oversight**
- Employee involvement in SMS
- SMA/SMS legal provisions
- Motivational, promotional, **awareness** activities
- SMA professional staff usage
- SMS/SMA implementation
- **Internal studies** and **external reviews**

Hazard and Risk Management

- Risk Management
    - **Risk identification** and mitigation
    - **Risk tracking**
    - **Lessons Learned**
    - GIDEP/ALERT/NASA Advisory
    - Personnel Reliability Program (PRP)
    - National Security
- Emergency/Contingency Preparedness
    - **Emergency Preparedness**
    - Fire Protection
    - Emergency drills/simulations
    - **Hazardous materials (radiation, toxics, energetics)**

Hazard and Risk Assessment

- Hazard Analysis and Human Protection
  - Setting safety goals
  - Safe performance of duties
  - **Communication of problems**
  - Safety surveys
  - **Hazard analyses and documentation**
  - Personal Protective Equipment
  - **Trend analysis**
  - Occupational Safety and Health Program
  - **NASA Safety Reporting System (NSRS)**
  - **Problem, failure, near-miss, mishap reporting, and root cause investigation**
- Product/Service Assurance Analysis and Product Protection
  - Product assurance goals
  - Identification of customer requirements
  - **Requirement/product control**
  - Development, **manufacturing**, & **operational** surveillance
  - **Assessment reviews**
- **Independent activities and assessments**
  - **Program evaluation**
  - **Program oversight**
  - **Process Verification**
  - **Independent Verification &Validation**
  - **Special assessment reviews**

Education, training, and outreach

- Management and accomplishment of training and education
- Federal interagency participation
- Range Safety

Performance targets and metrics

Research and development

SMA Roles and Relationship with Programs
February 8, 2003, 11:20 AM
Provided per request of Andrea Falk (February 7 at 1630). Voicemail request read at 1830 and voicemail returned.

Andrea, Let me provide some source material that will provide a high level perspective on role of SMA with the Programs/projects.

After you have assimilated this I would be very happy to review it with you.

Using as source material documents from our "tree" at
http://www.hq.nasa.gov/office/codeq/doctree/qdoc.htm#

Let's start with a fairly high level document that explains our Code Q mission role:

NPD 1000.3, paragraph 4.17
Excerpt:
http://nodis3.gsfc.nasa.gov/library/displayDir.cfm?Internal_ID=N_PG_1000_0003_&page_name=4.17

4.17 OFFICE OF SAFETY AND MISSION ASSURANCE (Code Q)

4.17.1. OFFICE MISSION. This Headquarters Program Office manages the safety and mission assurance program within the
Agency and exercises independent oversight authority for any activity that may adversely impact safety and mission success for
any NASA program or operation.

4.17.2. RESPONSIBILITIES. The Associate Administrator for Safety and Mission Assurance is responsible for the following:

4.17.2.1. Provides executive leadership, policy direction, functional management, assessment, and coordination for the
following:

a. Strategies, policies, procedures and guidelines, and standards for safety and mission assurance (hereinafter referred to as
SMA requirements).

b. Appropriate implementation of SMA requirements by the NASA Enterprise organizations.

c. Proper application of safety, reliability, maintainability, and quality (SRM&Q) disciplines and tools, techniques, and practices
throughout the program/project life cycle.

d. Process verification of SMA programs and processes and independent assessment of flight and ground systems to assure suitable attention has been given to risk assessment and risk management and that all SMA requirements are being met.

4.17.2.2. Assures effective maintenance and use of SRM&Q knowledge and resources at all NASA Centers and contractor facilities and supports Enterprise Associate Administrators and Center Directors in determining SRM&Q resource levels.

4.17.2.3. Advises NASA management on significant safety and mission assurance issues and oversees prompt investigation and closure for NASA mishap findings and recommendations.

4.17.2.4. Advocates and represents the NASA safety and mission assurance programs and requirements to Government, industry, and international participants.

4.17.3. SPECIAL RELATIONSHIPS.

4.17.3.1. The Associate Administrator for Safety and Mission Assurance serves as an ex officio member of, and provides administrative support to, the Aerospace Safety Advisory Panel, which reports directly to the Administrator.

4.17.4. LINE OF SUCCESSION. In the following order: Deputy Associate Administrator for Safety and Mission Assurance; Director, Safety and Assurance Requirements Division; Director, Enterprise Safety and Mission Assurance Division; and Director, Review and Assessment Division.

Change 30...December 16, 2002

Next, let's look at our top level Safety and Mission Success Document, NPD 8700.1

http://nodis3.gsfc.nasa.gov/library/displayDir.cfm?Internal_ID=N_PD_8700_001A_&page_name=main%20

Pertinent excerpts:

1. POLICY

It is NASA policy to--

a. Protect the public, Astronauts and pilots, NASA workforce, and high-value equipment and property from potential harm as a result of NASA activities and operations by providing safe programs, technologies, operations, and facilities; and protect the environment.

b. Hold NASA leaders, managers, supervisors, and employees accountable for safety and mission success within their functional areas of responsibility.

c. Establish and maintain independent lines of communications for unrestricted flow of information concerning Safety and Mission Assurance (SMA), risks, or other matters affecting the ability to meet the minimum mission-success criteria.

d. Define and document both SMA requirements and safety and mission-success criteria in NASA programs and projects as a foundation for the design and development of safe and reliable program hardware and software. All solicitation instruments (announcements of opportunity, cooperative agreements, requests for proposals, or other) will require prospective providers to identify and describe SMA and Risk Management (RM) approaches (where appropriate) and how the risk factors will be managed.

e. Verify and validate life-cycle implementation of SMA, RM, and mission-success requirements through ongoing surveillance of program, project, and contractor processes.

f. Certify the safety and operational readiness of flight hardware/software, mission-critical support equipment, hazardous facilities/operations, and high-energy, ground-based systems through formal review processes.

g. Fully address safety and mission success concerns, risks and risk acceptance, and appropriate lessons learned at all management council reviews, other major milestone review activities, and operational readiness reviews.

h. Implement structured RM processes and use qualitative and quantitative risk-assessment techniques to make optimal decisions regarding safety and the likelihood of mission success.

i. Report and track to resolution all corrective actions approved and resulting from investigations of mishaps, incidents, nonconformances, and anomalies; and distribute and use lessons learned to improve activities and operations.

5. RESPONSIBILITY

a. Each NASA organizational element shall allocate and maintain appropriate levels of authority, funding, and training necessary to achieve compliance with the policies set forth above.

b. The Enterprise Associate Administrators are responsible for the safety and mission success of their Enterprise programs, projects, and activities. To accomplish this, each Enterprise Associate Administrator shall--

(1) Provide executive leadership in implementing Agency Safety, Reliability, Maintainability, and Quality (SRM&Q) and RM policies, plans, techniques, procedures, and standards throughout all Enterprise programs, projects, and activities.

(2) Ensure that safety and mission-success requirements are defined for all Enterprise programs and projects and that a process for recurrence control of problems is accomplished through a closed-loop corrective and preventive action system.

(3) Establish Enterprise policies and procedures for formal reviews for the certification of programs, projects, and activities as detailed in paragraph 1.f.

(4) Coordinate with the responsible Functional Offices to ensure that domains of potential risk (information management, environment, security, legal) are properly included in RM plans.

(5) Serve as the final risk acceptance/disposition official for Enterprise programs, projects, and activities.

(6) Formulate and approve, in coordination with the Associate Administrator for Safety and Mission Assurance, an Enterprise SMA Agreement (see Attachment A).

(7) Approve Center SMA Annual Operating Agreements.

(8) Provide an annual status report to the Administrator on the Enterprise actions to support the Agency mishap-prevention program.

c. The Associate Administrator for Safety and Mission Assurance shall--

(1) Provide SMA and RM executive leadership, policy direction, and implementation assessment to all Agency programs, projects, and activities.

(2) Establish strategies, policies, agreements, and standards for SRM&Q and RM and ensure effective compliance with same. This includes providing SRM&Q and RM expectations and evaluations at Program Management Council activities and other major program milestone reviews.

(3) Evaluate the Agency for the existence of effective and efficient SMA and RM functional management processes for assuring safe and successful NASA programs, projects, and activities. These assurance evaluations include (a) establishing, approving, and maintaining Enterprise SMA agreements with each NASA Enterprise; (b) reviewing and concurring with each Center's SMA Annual Operating Agreement; (c) conducting periodic SMA process verifications of Centers and Headquarters (for Headquarters, safety only) and tracking recommendations and corrective actions to closure; (d) ensuring that each Center has designated an SMA functional manager; and (e) providing SMA input to performance planning and annual performance evaluations for Enterprise Associate Administrators, Center Directors, and Center SMA functional managers.

(4) Direct the suspension of any operation that presents an immediate and unacceptable danger to personnel, property, or mission operations.

(5) Ensure that appropriate surveillance and independent assessments are conducted to verify that proper SMA practices are implemented and SRM&Q risks are properly identified and dispositioned for all NASA programs, projects, and activities.

(6) Establish review processes to certify the safety and operational readiness of flight hardware/software, mission-critical support equipment, hazardous facilities/operations, and high-energy ground-based systems.

(7) Participate in selected certification reviews established by the Enterprises.

(8) Develop and implement a process to evaluate safety risks associated with requests for liability insurance or indemnification pursuant to 42 U.S.C. 2458c (see NPD 8700.2).

(9) Direct and oversee (in coordination with the appropriate Enterprise Associate Administrators) the prompt and accurate reporting, investigating, and analyzing of all NASA mishaps and close calls, including closure of problems, nonconformances, and anomalies, and assure the collection, retention, and communication of their lessons learned as one means of recurrence control.

(10) Formulate and direct SRM&Q education, training, and career development programs to enable SMA staff, program/project management, Senior Management, and the NASA workforce to obtain the understanding of SRM&Q principles, tools, methods, and standards necessary to successfully perform their functions.

(11) Appoint an SMA liaison to serve as the matrixed safety officer for each Enterprise Associate Administrator.

(12) Develop, maintain, and update a Process-Based Mission Assurance (PBMA) Knowledge Management System (KMS), derived in part from NASA, DOD, and aerospace industry best practices and lessons learned, which may be used to assist NASA program/project managers in planning for and implementing safe and successful programs.

(13) Assure PBMA-KMS functionality to assist managers in developing appropriate safety, RM, and mission-success language for NASA solicitations, acquisitions, cooperative agreements, and requirements for inclusion in program and project plans.

(14) Develop and maintain systems to capture SMA knowledge, best practices, and lessons learned to assist NASA managers in developing safety, RM, and mission-success requirements and in planning and implementing safe and successful programs.

(15) Support the development and rapid transfer of new SMA technologies, processes, and methodologies to various market sectors and Government agencies.

(16) Serve as NASA's SMA technical representative and liaison to other Government agencies and outside organizations.

d. The Center Directors are responsible for the safety and mission success of their activities and operations. To accomplish this, each Center Director shall--

(1) Maintain the safe and successful functioning of facilities and operations, use lessons learned to improve operations and activities, and prevent recurrence of undesired events through a closed-loop corrective action process.

(2) Implement Agency SRM&Q policies, plans, techniques, procedures, and standards and ensure that safety and mission-success requirements are established for Center operations and activities.

(3) Serve as the final risk acceptance/disposition official for Center activities. Assure that any delegation of this authority is performed based on an assessment of the frequency of occurrence and the severity of the risk.

(4) Designate a functional manager for SMA to serve as the leader and focal point for the Center's SMA activities.

(5) Staff Center SMA organizations with qualified SRM&Q and RM professionals.

(6) Develop and approve the Center's SMA Annual Operating Agreement.

e. Program and project managers are responsible for the safety and mission success of their program/projects. Program and project managers shall--

(1) Implement Agency SMA and RM policies, guidelines, and standards and establish safety and mission-success requirements within their programs and projects.

(2) Develop, in coordination with the responsible Center SMA functional manager(s), the program and project RM plans; establish/maintain a mission-risk profile; and serve as the final risk acceptance/disposition official for activities within their program/project.

(3) Coordinate with the responsible functional offices to ensure that other domains of potential risk (information management, environment, security, legal) are properly included in RM plans.

(4) Use and distribute lessons learned to enhance the probability of mission success and establish recurrence control through a closed-loop corrective/preventative action system.

(5) Designate an individual with specific responsibilities for coordinating/executing SMA efforts within the program/project.

f. The Center SMA functional managers shall--

(1) Provide local SMA executive leadership and policy implementation direction for Center-level projects and operations.

(2) Serve as the Center focal point for the alternative, independent SMA line of communication.

(3) Assure that effective and efficient SMA processes are in place to enhance the potential for success of NASA programs, projects, and activities at the Center level.

(4) Conduct surveillance and independent assessments to enhance (a) the success of programs, projects, and activities; and (b) the effectiveness of SMA activities. This includes overseeing any SMA activities managed by other organizations, such as aviation safety, lifting safety, pressure-systems safety, firefighting, and emergency response.

(For a list of typical SMA activities and program elements, see Attachment A.)

(5) Direct the suspension of any operation that presents an immediate and unacceptable risk to people, property, or mission operations.

(6) Review, in coordination with their Center's program and project personnel, SMA, and RM plans for the programs and projects at the Center.

(7) Provide in-line support to projects and programs by performing hazards analyses and SMA assessments in support of project and program needs.

(8) Provide SMA expectations and evaluations to local Governing Program Management Council activities.

(9) Assist the Center Director in formulating the Center SMA Annual Operating Agreement (see paragraph 5.d(6)).

(10) Provide the SMA products and services agreed to in the applicable SMA Annual Operating Agreement.

(11) Assure the prompt and accurate reporting, investigating, tracking, and closure of all mishaps, close calls, problems, nonconformances, and anomalies within the Center's jurisdiction. This includes collection and retention of lessons learned as one means of recurrence control.

(12) Identify the need for and support the development of new SRM&Q and RM tools, techniques, and processes.

g. The Director, Office of Headquarters Operations, is responsible for the operational safety program at Headquarters. The Director shall--

(1) Maintain the safe and successful functioning of facilities and operations, use lessons learned to improve operations and activities, and prevent recurrence of undesired events through a closed-loop corrective action system.

(2) Implement Agency safety policies, plans, techniques, procedures, and standards and ensure that safety requirements are established for Headquarters operations.

(3) Direct the suspension of any operation that presents an immediate and unacceptable risk to people, property, or operations.

(4) Serve as the final safety risk acceptance/disposition official for

Headquarters activities.

(5) Designate a safety manager to serve as the leader and focal point for the Headquarters safety activities.

(6) Establish and track safety metrics.

h. Supervisors and managers are responsible for educating their employees on the hazards of their job, establishing and promoting safe work practices, instilling in employees the importance of safety and mission success, and implementing safety and mission success regulations.

i. Employees are responsible for understanding the safety and mission-success requirements of their organization, performing their tasks in accordance with established safety procedures, and using prescribed personal protective equipment.

Additional words on safety philosophy and guidance may be found in our Agency Safety Manual: NPG 8715.3

http://nodis3.gsfc.nasa.gov/library/displayDir.cfm?Internal_ID=N_PG_8715_0003_&page_name=main

Excerpts:

The chapters of interest are in Chapter 1 and 5; I would excerpt those but it comes out real messy so I would prefer you use the hot link above. This is document is very complex and is filled with requirements that in themselves would take pages to fully explain. Take a look to see if there is anything here of interest.

We have another series of documents that relate the interface between Code Q and the Enterprises. These documents are presently being revised and the materials that I am linking are somewhat dated but perhaps of general value to understand the relationships here at Agency HQ level.

http://www.hq.nasa.gov/office/codeq/doctree/apr.htm

A document of interest is probably the DRAFT NPG 8705.TBD SMA Requirements for Human Exploration and Development of Space (these are procedures and guidelines for the various processes) which details the process for interface with the Human Spaceflight processes including the launch decision process. This accurately reflects what we do but as you see is in a draft stage. Our desire here is to document the process for others to understand.

Andrea, that probably provides a high level description of the relationships between SMA and Program and the underlying philosophy of the Agency allocation of roles.

As I offered at the top I would be happy to review your thesis when complete.

Questions that may be addressed:

1. What is NASA's Independent Risk Assessment Process?
2. How does NASA Identify, track, and manage risk?
3. Since Challenger in 1986, how many times has SMA Reported to Congress, Science and Technology Committee on the status of NASA's Independent Assessment Process?
4. What types of Independent Assessments have been completed since Challenger?
5. What are the results and trends of these reviews?
6. As NASA Administrator, what is your view of the robustness of the NASA Independent Risk Assessment Process?
7. How well has the NASA Independent Risk Assessment Process been funded in your budget? Is this budget adequate?
8. Have any of your funds been used to support "special program studies" to help bolster the program's (STS, Station) budget?
9. What process needs to be enhanced to preclude this from happening again?

Jon Mullin

Brief Description of Faith's Possible Contributions to the Investigation

Fault Tree / Root Cause Analysis

Provide assistance by:

- Creating fault trees and/or performing root cause analysis for the investigation.
- Checking logic/flow of fault trees created by others.
- Ensuring that trees are comprehensive and include all possible areas by using the IAT-M and other investigation tools.
- Verify that fault trees/root cause analysis has adequately included and analyzed human error and unsafe actions.
- Verify that the analysis has gone beyond the identification of proximate causes and has identified root causes.

Mishap Investigation Methodology & Protocol

Provide assistance by:

- Developing and providing training briefings for the CAIB.
- Assist CAIB work through the investigation process …create three column list, create time line (or evaluate time line for completeness), create fault trees, create event causal-factor tree, perform change analysis, perform barrier analysis, complete root cause analysis, organize report per NPG.
- Verify that the report contents have desired elements and facts flow to findings and recommendations.
- Assist CAIB interview witnesses (e.g., prepare questions for interviews).

Human Factors

Provide assistance by:

- Evaluating the impact of human actions/ errors in the processing, operations, and decision making of Columbia's launch.
- Assist in the development of branches of the fault tree/event tree and root cause analysis that indicates human action was a factor.
    - Evaluate potential errors that could have occurred in the foam processing (e.g., development of a Human Factors FMEA for foam processing, HF FMEA for decision making leading to acceptance of risk, or perform similar analysis for legs of the tree that appear to be significant).
    - Assist in the evaluation of team errors and performance that may have contributed to the accident.
- Coordinate the Human Factors analysis in the investigation… identify and lead a team of seasoned (e.g., from FAA, NTSB, DOD, etc) to evaluate the accident from a human factors perspective.

Accident and Risk Management in Space Program

- NASA first priority is ensuring the safety of our crews and the public.

- Our programs and processes are designed to ensure that safety is pursued as our paramount goal. NASA's culture emphasizes that each employee is responsible for safety, both for their immediate work environment and for the space flight program as a whole.

- NASA's formal risk management strategy maximizes safety and reliability within the technological and operational constraints of space flight, while maintaining safety as the first priority.

- The Space Shuttle Program uses a variety of qualitative and quantitative methods to characterize the risk. All levels of NASA staff are engaged in ensuring the safety of our crews and the public, including program management, technical experts, flight crew representatives, and the NASA safety community.

- The program manager has the ultimate responsibility for risk management and is accountable for ensuring that risk analyses, appropriate to the complexity of the potential risk, have been conducted and that the analysis demonstrate that the program is operated in a safe manner.

- NASA Headquarters Office of Safety and Mission Assurance (Code Q) works in cooperation with center safety and mission assurance organizations to manage risk in the space flight programs. Code Q is responsible for:

  - Reviewing the day-to-day detailed planning process;
  - monitoring the overall planning and implementation processes;
  - ensuring that such areas as schedule, overtime rates, spares availability, and reviews do not adversely affect safety; and
  - identifying any trends or indications of potential problem areas.

- There are several elements to the NASA risk management system:

  - *Failure Modes and Effects Analysis (FMEA).* A FMEA is performed on each component of the Shuttle system to identify hardware items that are critical to the performance and safety of the vehicle and mission.

  - *Critical Items List (CIL).* The CIL is a listing of components and their failure modes which, if they fail in one of the potential modes identified in the FMEA, could result in loss of vehicle, life, or mission.

  - *Hazard Analysis (HA).* In addition to evaluating the risk resulting from the failures identified in the FMEA process, these analyses identify the presence of other potential risks caused by the environment, crew machine interfaces, and mission activities. Any hazards remaining after all feasible design or procedural corrective efforts are implemented are termed accepted risks and require review and approval by the Space Shuttle Program Manager.

- In addition, NASA uses a system of integrated reporting to document identified problems and lessons-learned throughout the space flight system.
  - *Mishap Reporting*. A standardized mishap reporting and corrective action system has been implemented that requires management review and approval of all corrective action plans and provides a mechanism for disseminating lessons-learned summaries through electronic communications.
  - *Problem Reporting*. An inter-center problem reporting and corrective action information system and a program compliance assessment status system are being developed to assist in the analysis and reporting of significant problems and trends.
  - *NASA Safety Reporting System (NSRS)*. A supplemental safety information channel, the NASA Safety Reporting System (NSRS) has been implemented to enable NASA and contractor personnel to notify NASA of safety problems or hazards that could potentially result in loss of mission capability. Using this system, individuals are able to communicate safety concerns to an independent agent when, in their opinions, standard reporting channels lack the proper degree of response to a critical problem.

U:\STS 107 Mishap\Accident and Risk Analysis in Shuttle Program.doc
4/28/2003 10:25 AM

Approved:

M______________________

Q______________________

A______________________

Pre- and Post-Challenger Safety Approach

Pre-Challenger

- Schedule-focused
- FRR
  - ✓ Conducted via telecon
  - ✓ Partial participation
  - ✓ Inconsistent participation
  - ✓ Unclear areas of responsibility
  - ✓ Center-focused rather than element-focused
  - ✓ Informal documentation
- Unclear responsibility for implementation of NASA requirements
- No formal participation from safety officials, no independent safety assessment
- Low-level of rigor and consistency in process
- Flawed decision-making process
  - ✓ Launch constraints waived at expense of safety
  - ✓ No process for ensuring all levels of management consider waivers
- Culture did not encourage communication of issues and problems
- Contingency Action Plan was outdated and not regularly exercised

Post-Challenger

- Safety-focused
- FRR
  - ✓ Conducted in person, no participation via telecon
  - ✓ All key personnel (NASA and contractor) in attendance
  - ✓ Clear areas of accountability
  - ✓ Polling by system readiness
  - ✓ Formal documentation
- Clear responsibility for implementation of requirements
- Structured, consistent process that encourages problem identification and offers of minority opinions
  - ✓ All waivers and constraints must be reviewed
  - ✓ Astronauts in management positions
- Safety focus is visible and independent.
  - ✓ AA for S&MA established
    - is an FRR Board Member
    - concurs by signature on the readiness to proceed with mission
- Increased contractor participation and accountability
- Contingency Action Plan is updated for each flight and regularly exercised

NASA Response to Challenger vs. Today's

THEN (1986)

- Rogers' Commission stated, " For the first several days after the accident – possibly because of the trauma resulting from the accident – NASA appeared to be withholding information from the public."
- No one was prepared for a catastrophe. Contingency Action Plan was not in place
- Apparent NASA confusion about roles and responsibilities. Lack of leadership evident.
- NASA investigation team was seen to lack independence from the engineers who were in the launch decision process.
- Situation led Rogers' Commission to switch from role of Oversight to Direct Investigation. New approach briefed to Congress 20 days later.

NOW

- More realistic view of the risks involved in space flight.
- Decision accountability clear and well documented in open fora.
- Contingency Action Planning is robust, updated for each flight, and exercised routinely (last simulation was in Nov 2002).
- Standing External Board independent from NASA in place for each flight.
- External Board called up and on-site the next day.

Rogers' Commission Timeline

- Jan 28--Challenger Mishap
- Feb 3--President Reagan announces formation of Oversight Commission via EO 13546
- Feb 6--Chairman Rogers sworn in and began hearings as to the status of NASA's investigation
- Feb 10—Executive Director appointed and began to assemble group of 15 experienced investigators.
- Feb 10—Commission, in closed session, began to learn of the troubled history of the SRM joint and seal and the launch decision process
- Feb 15—Role changed from oversight to active investigation because Chairman saw people involved in the internal investigation team were also involved in launch decision. divided into four panels.
- Feb 17—Commission Organization finalized.
- Feb 18—Rogers briefed Hill on new approach: investigation vice oversight.
- Feb 25-27—Public Hearings.
- March to June—Continued investigative activity.
- June 6—Commission submitted report to the President.

02/7/03, 1:00 PM

Questions and issues submitted to NASA Headquarters Office of Safety and Mission Assurance for consideration by Bryan O'Connor.

Questions are listed in the chronological order in which they were received and the author is noted.

02/10/03, 7:23 AM, Joe Wonsever, SMA, GSFC

160. From the press reports, it certainly seems that the most likely cause was tile damage from a tank insulation hit. All of the following therefore should be thought of as a way to confirm the most likely cause (or a variant thereof) and to leave no stone unturned in the search for possible other causes. Obviously, there are scads of routine things that should be checked and I assume are being checked. Certainly all records with respect to processing (and QA) for the tank insulation application. Same for tile application. Same for landing gear door closeouts. All processing and QA records for the past several years should be checked for problem trends for tank insulation application and tile installation. All work performed during the recent Columbia refurbishing should be reviewed for possible issues that could be relevant. The thermal engineers should be tuning up their CAD models to try to duplicate the signature of the combined set of thermal TM during reentry (i.e., what heat load, placed where, increasing at what rate, no doubt with changes in rate as damage progressed, etc. would produce the observed TM?). The aero guys should be doing similar work trying to replicate the aero signature. Some perhaps less obvious items are below (in no particular order):

   a. Assuming the crew observed and commented on the tank condition after separation, were their comments on the condition of the tank (missing insulation) consistent with the hypothesized size of the debris from the photos?
   b. If I recall correctly, there are doors on the orbiter underside which close at tank separation to seal off the H2 and Lox lines. I'm not sure if there are microswitches or other sensors to indicate door closure, but in any case: Was all telemetry for the door closing nominal (including expected timing)? Could tank debris have prevented full closure of a door (via damage or obstruction) and is there TM that would have detected that condition? Could debris have lodged in a location so as to give a false indication of the door being fully closed? Could a debris hit compromise the latching mechanism in a way that TM wouldn't detect (and would aero forces tend to keep the door closed or pry it open)? I don't recall how the electrical connections to the tank are made - Do the electrical umbilical go through the same or separate doors? If separate, the same questions apply to those doors.
   c. The press has been unclear about whether the tank was the old design or the lightweight version. In any case, were there any process changes with

respect to insulation application for the lightweight tank? If the process was changed, was the correct process used for the STS-107 tank (i.e., if an old design tank was flown, was the old process used, and vice versa)? If the process wasn't changed (and if a lightweight tank was used on STS-107), was the process revalidated for the new tank material? If the tank was the old design, was it a hanger queen (i.e., How old was it compared to age of other tanks when flown? Are there any storage/handling anomalies? Etc.)

d. If our own resources weren't used for high resolution images of the Columbia underside during the mission, have we checked for other possible image sources (i.e., clandestine assets, foreign assets, amateur observers with access to a good enough telescope, etc.)? A world wide call for images might be appropriate.

e. Were there any TM indications (i.e., abruptly lost TM point, etc.) or crew comments that might be consistent with a significant orbital debris hit on the orbiter underside at any time during the mission? How big a piece of debris at what velocity would be needed to do fatal damage with respect to thermal control on reentry and would such a hit be likely to have been heard (transmitted through the structure into the cabin) and commented on by the crew?

f. Does any of the launch tracking imagery contain spectral data that could be examined to give an indication of how much tile material might have been dislodged/destroyed by the debris hit at 80sec.? (My guess is that this is highly unlikely, but you don't know if you don't ask.)

g. The thermal (and structural) models for the various control surfaces should be reanalyzed to confirm that the unusual control surface deflections (per the press reports, outside prior experience) would not result in thermal (or structural) loads sufficient to cause a failure. Were there assumptions in the models that the vehicle would be symmetric or did they account for the possibility that a control surface might be kept in a significantly deflected position for an extended time period? Were hinge lines, gaps, etc. modeled in detail for possible hot spots if kept in a deflected position for an extended period?

h. Was the tank separation clean and normal? Specifically, were there any anomalous tip-off rates (or anything else in the TM) that might indicate a partial hang-up or other problem at the left rear orbiter attach point that could have left damage that was vulnerable to reentry heating?

i. Various radars have filters associated with their intended purpose (ATC, weather, etc.). For any radars sites that might have recorded raw data of the early reentry, we should assess whether that raw data (possibly looked at with a custom filter) could reveal if/when/where any small debris might have come off during the early portion of the reentry.

As of: Noon, Feb. 10, 2003

Code Q input to Questions to be Addressed at the Joint House/Senate Shuttle Hearing on 2/12/03

4. With over 6,800 single point failures on the Space Shuttle, what is an acceptable level of risk that the nation is willing to accept in pursuit of human spaceflight activities? (Code Q/O'Connor with support of M/Readdy)

Code Q recommends the following answer (we have provided these words to Code M, as well):
The first probabilistic risk assessment of the Space Shuttle that calculated a number for the risk of catastrophic accident on ascent was completed in 1989. That number was 1/78 and was widely cited in newspaper accounts at the time. The nation continued to support the flight of the Shuttle, despite their knowledge of the risk level. While subsequent updates and refinements of the risk numbers for the Shuttle actually improved (as a result of additional flight and test data, and incorporation of actual Shuttle upgrades into the PRA models), these risk numbers were not widely publicized. The numbers were, however, shared with the Congress on more than one occasion in the last 4-5 years in the context of funding needed for the Shuttle Upgrades Program.

Very recent public opinion polls (since the Columbia accident) seem to demonstrate that the public overwhelmingly favors continuing the exploration of space and is willing to accept the risk even though the public's perception of Shuttle risk is now based on 2 failures in 113 flights, or a demonstrated catastrophic failure probability of approximately 1/56.

a. Was NASA's risk analysis for Shuttle safety (1 in 265 chance of failure) prior to the Columbia accident realistic?

Code Q Action Leads – Pete Rutledge and Mike Stamatelatos (prutledg@hq.nasa.gov)

Code Q recommends the following answer be added to that proposed by Code M (we have provided these words to Code M, as well):
The probability of rare events such as the catastrophic failure of the Space Shuttle, requires the development of mathematical models based on a methodology called probabilistic risk assessment (PRA). A very important strength of PRA is that it recognizes uncertainty to be inherent, i.e., a fact of life. Uncertainties are generally things that "we know we don't know and those that we don't know that we don't know" (a recent quote about uncertainty from Secretary Rumsfeld). Uncertainties are described in a PRA in terms of mathematical probability distributions. Uncertainties are provided because exact values of the sought probabilities are never known. The PRA model yields a probability distribution whose mean (average) or median (50% confidence value) typically describe the probability of interest. The

Quantitative Risk Assessment System (QRAS) model calculated the median probability of the catastrophic failure of the Space Shuttle to be 1 in 265 (1/265). The probability distribution also expresses the degree of confidence in the quoted probability numbers. For example, the associated high (95%) confidence number from the QRAS model is 1 in 130. As more Shuttle flights occur and the experience database increases, the calculated distribution can be updated using statistical techniques yielding a new distribution which generally tends to have a narrower uncertainty range than the previous distribution. Also, the current PRA effort being conducted now by the Space Shuttle program is expected to yield a more accurate probability distribution than the previous ones.

8. Did NASA workforce reductions on the Space Shuttle program (from 3,000 to 1,800 full time employee reductions between FY 1995-99) heighten risks to the Space Shuttle fleet? (Code M/Readdy with support from Q/O'Connor)
Code Q Action Leads – John Lemke and Dale Moore (jlemke@hq.nasa.gov)
Concur with the response proposed by Code M

11. Did budget cuts to the Space Shuttle program over the last 10 years contribute to systemic safety problems with the Space Shuttle? (Code M/Readdy with support from Code Q/O'Connor)
Code Q Action Leads – John Lemke and Dale Moore (jlemke@hq.nasa.gov)

In addition to the response proposed by Code M, Code Q suggests the following be added (we have provided these words to Code M, as well): An important point to remember is that prior to the Challenger mishap, there was a general tendency to assume that the Shuttle was safe to launch unless proven otherwise. After Challenger, NASA changed this approach to one in which the Shuttle cannot launch unless it is proven safe.

16. Were any safety procedures short-changed in the Space Shuttle program as a result of budget cuts over the last 10 years? (Code M/Readdy with Q/O'Connor support)
Code Q Action Leads – Pete Rutledge (prutledg@hq.nasa.gov)

Code Q recommends that the word "reduce" be changed to "eliminate" in the last sentence of Code M's proposed response (we have provided this recommendation to Code M, as well).

24. What is the difference between the approach of the Rogers Commission and the approach laid out by NASA? (Code G/Mannix)
Code Q Action Leads – Wayne Frazier (wfrazier@hq.nasa.gov)

Code G is formulating the answer to this question based, in large part, on Code Q input.

Attachment 2

Questions to be Addressed at the Joint House/Senate Shuttle Hearing on 2/12/03

MSFC Response in Blue

8. Did NASA workforce reductions on the Space Shuttle program (from 3,000 to 1,800 full time employee reductions between FY 1995-99) heighten risks to the Space Shuttle fleet? (Code M/Readdy with support from Q/O'Connor)
Code Q Action Leads – John Lemke and Dale Moore (jlemke@hq.nasa.gov)
    - Even though personnel level of effort increased, no corners were cut in assuring Shuttle safety

11. Did budget cuts to the Space Shuttle program over the last 10 years contribute to systemic safety problems with the Space Shuttle? (Code M/Readdy with support from Code Q/O'Connor)
Code Q Action Leads – John Lemke and Dale Moore (jlemke@hq.nasa.gov)
    - All Shuttle hardware issues are addressed with the up most rigger and there is no correlation between budget cuts and safety problems

16. Were any safety procedures short-changed in the Space Shuttle program as a result of budget cuts over the last 10 years? (Code M/Readdy with Q/O'Connor support)
Code Q Action Leads – Pete Rutledge (prutledg@hq.nasa.gov)
    - The approached used by NASA in transitioning from oversight to insight in the Mid 1990's was systematic and thorough. All critical assurances were retained.

Space Shuttle Program Assessments

Title: Process Readiness Review Space Shuttle Program Space Flight Operations Contract (SFOC) United Space Alliance An Independent Assessment of SFOC/USA-Ground Operations, NASA/SFOC Flight Operations, and NASA/KSC Safety and Mission Assurance
Author: NASA Office of Safety and Mission Assurance
Date: October 27, 1998
Abstract: This is a summary report of the NASA Office of Safety and Mission Assurance's (OSMA) independent assessment of USA Ground Operations processes at Kennedy Space Center (KSC), USA Flight Operations processes at Johnson Space Center (JSC), and NASA Safety and Mission Assurance (SMA) processes at KSC. OSMA also examined the readiness of KSC/SMA to support the International Space Station (ISS). This review was initiated in response to staff reductions, specifically 552 full time employees in the USA ground operations workforce that occurred between January and July 1998. The review set out to "independently assess the readiness of both USA and NASA flight-critical process to safely accommodate the increased flight rate at current staffing levels and skill mix.

Title: Space Shuttle Ground Operations Independent Review of United Space Alliance Strategic Initiative Implementation
Author: NASA Office of Safety and Mission Assurance
Date: April 19, 1999
Abstract: This is the report of the NASA Office of Safety and Mission Assurance's (OSMA) Process Readiness Review (PRR) of USA Ground Operations (USA/GO) processes at Kennedy Space Center. This independent review provides a follow-on assessment of outstanding issues identified in the October 27, 1998, PRR. This series of reviews was set in motion by staff reductions in the USA workforce, occurring as a result of Space Shuttle program resource constraints, coupled with the need to accommodate an increase in the flight rate.

Title: Independent Assessment of Space Shuttle Ground Operations Processing Capability Workforce Survey – Kennedy Space Center April 30 – May 2, 2001
Author: NASA Office of Safety and Mission Assurance
Date: October 31, 2001
Abstract: This is the report of the NASA Office of Safety and Mission Assurance's (OSMA) independent assessment of Space Shuttle Ground Operations Processing Capability. This study follows up two previous studies involving staff reductions occurring in the United Space Alliance Ground Operations (USAGO) workforce between January and July 1998 and USAGO process initiatives and derived efficiencies. The present study examines workforce capability from the perspective of workforce satisfaction and attitudes toward safety and workplace stress under a four-orbiter-in-flow condition. A second related objective was to assess the value and usefulness of current work time deviation (WTD) metrics in monitoring and managing individual and aggregate workforce stress and fatigue.

Title: Space Shuttle Super Lightweight Tank (SLWT) Independent Assessment of Risk Management Activities
Author: NASA Office of Safety and Mission Assurance
Date: December 12, 1997
Abstract: This is a report of the NASA Office of Safety and Mission Assurance's (OSMA) assessment of the Marshall Space Flight Center (MSFC) and Lockheed Martin (LM) implementation of the safety and risk management processes used to provide confidence that the Super Lightweight Tank (SLWT) program will operate safely, achieving mission success. The OSMA SLWT safety and risk management evaluation team finds that risk issues and other concerns identified by the SLWT program and numerous independent assessment teams have been properly managed and dispositioned.

Problem Reporting and Corrective Action

The Space Shuttle Program uses the following two documents for problem resolution:

- NSTS 08126, Problem Reporting and Corrective Action System Requirements
- NSTS 37325, JSC Orbiter Problem Reporting and Corrective Action Requirements

In summary:

- All problems must be interim dispositioned or closed prior to flight.

- All problems are also assessed to determine if the anomaly is a constraint to flight.

- Problems become "flight constraints" whenever the problem cannot be accommodated by one of the following:
  - Existing flight rules/crew procedures,
  - Basic subsystem redundancy,
  - Or has other implications that clearly present a safety of flight issue.

- The Space Shuttle Program Office and the Space Shuttle Program SR&QA Office is notified of the "flight constraint". The Problem Resolution Team and Management Team determine the follow-on actions required to clear the "flight constraint". Some of those activities (risk assessment) may include:
  - Test/Teardown and Evaluation
  - Failure analysis to understand the problem
  - Remedial or corrective action to correct the problem.
  - Analysis
  - Modeling
  - Simulation

- The rationale/resolution for clearing the "flight constraint" must be approved by the Space Shuttle Program Office and SR&QA Office.

- Problems that are not flight constraints are processed with interim or closed dispositions. Interim disposition is acceptable based on one of the following criteria:

  a. The problem is not applicable to the flight(s) (i.e., system not installed and/or used on the flight).

  b. The problem condition is clearly screened during preflight checkout or special tests.

  c. The problem is time/age/cycle related and the flight units will accumulate less than 50% of the critical parameter(s) by the end of the flight.

  d. There is no indication of a generic problem.

  e. There is no overall safety of flight concern.

  f. The problem is applicable to the flight(s) (system used during flight); however, the PRCB agrees that sufficient evidence exists that the system can be flown safely (acceptable risk).

- Reportable problems experienced after the SSP Flight Readiness Review (FRR) through completion of the element's mission phase or during a flight which could potentially affect flight, ground crew safety, or mission success will be reported to the appropriate Design Element Office as soon as possible but no later than one working day from detection. If the problem occurs preflight, it must be reported to the Design Element Office prior to launch. Design Element Office managers are responsible for reporting significant problems to the Program Requirements Control Board (PRCB) or Mission Management Team (MMT) to support launch or flight decisions.

Certificate of Flight Readiness Process

- The Space Shuttle Program utilizes NSTS 08117, Requirements and Procedures for the Certification of Flight Readiness (COFR) to define the Space Shuttle Program (SSP) Flight Preparation Process (FPP). It defines the procedures for the Project Milestone Reviews, the Program Milestone Reviews and the Flight Readiness Review (FRR). It also defines the endorsement documentation required at the completion of the FRR, which provides the Certification of Flight Readiness (CoFR) for a specific flight.

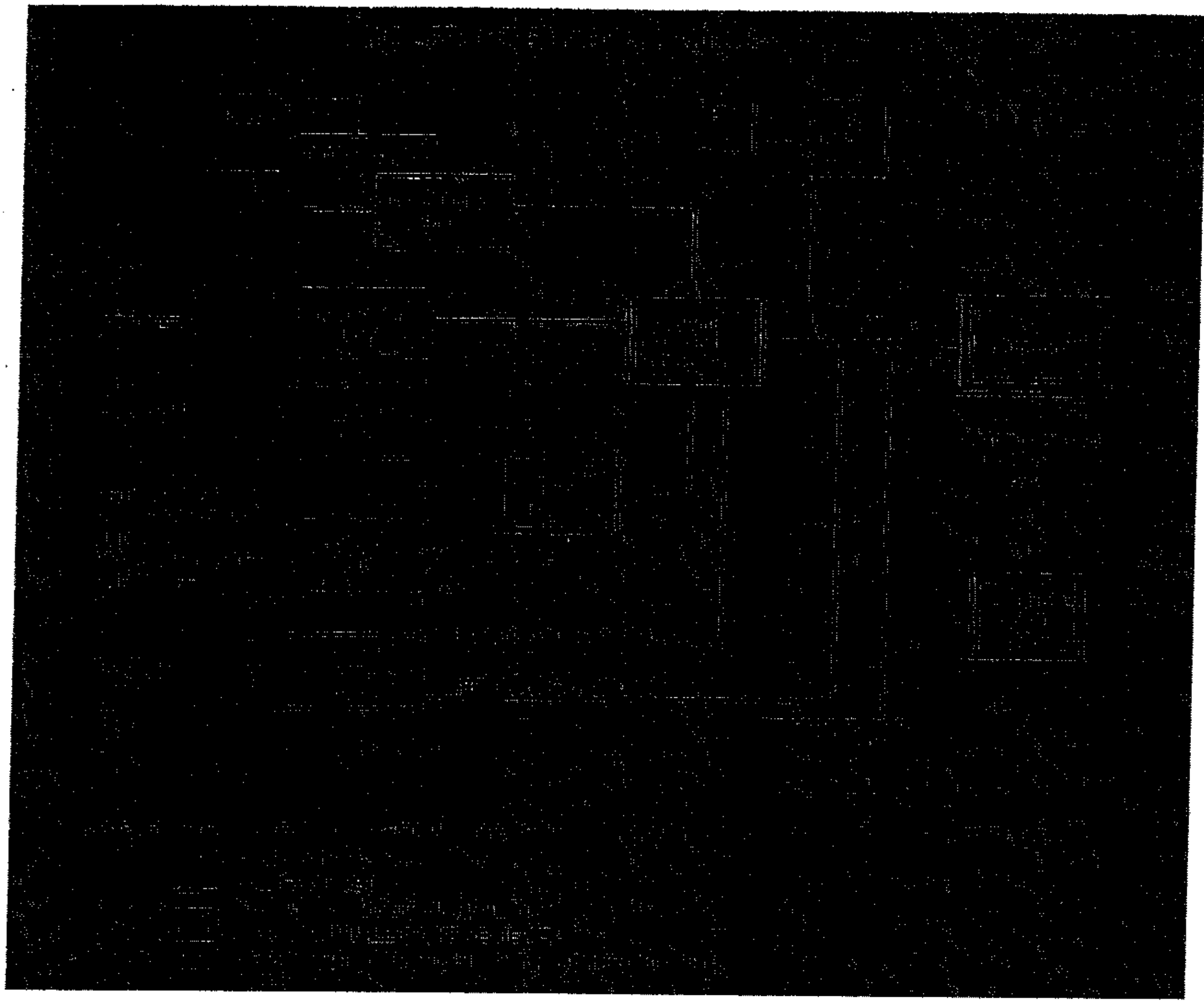
- NSTS 08117 is applicable to JSC, KSC, MSFC, Stennis Space Center (SSC), and SSP NASA and contractor organizations and personnel involved in the conduct of Space Shuttle operations. The FPP consists of the required preparations for a Space Shuttle mission, from the baselining of the processing requirements to acceptance of the major hardware elements through processing, mating, launch, and ferry when required. The major FPP elements are:

  - The Project Milestone Reviews.
  - Three Program Milestone Reviews.
  - and the FRR where the CoFR endorsement is signed.
  - Reviews of the activities that support the FPP are considered part of the CoFR process.

- The Flight Preparation Process (FPP) is structured as follows::

  - The FPP is structured to baseline a set of processing requirements through a series of requirements reviews and to incrementally review and status progress towards readiness for flight (see reference Figure 1).
  - It represents a commitment by each of the SSP element and project managers (NASA and contractor) certifying that their organizations have satisfactorily completed the requirements and their respective portions of the effort required to safely support each flight.
  - The FPP is incrementally implemented through milestone reviews and an FRR which ensures the readiness of all organizations for the operational phase following each review.
  - The FPP consists of Project Milestone Reviews, three Program Milestone Reviews and the FRR.
  - The Project Milestone Reviews are the DD 250/1149–Element Acceptance Reviews, the Payload Readiness Review (PRR), the Software Readiness Review (SRR), and the organizational Pre–FRR Reviews.
  - The three Program Milestone Reviews are the Pre–Mate Milestone Reviews, consisting of the External Tank (ET)/Solid Rocket Booster (SRB) Mate Milestone Review and the Orbiter Rollout/ET Mate Milestone Review, and a Ferry Flight Readiness Milestone Review which is conducted when a ferry is required.
  - The CoFR endorsement is signed at the FRR.
  - A Prelaunch Mission Management Team (PMMT) Review will be conducted on the Launch Minus Two (L–2) Day or Launch Minus One (L–1) Day when the Mission Management Team (MMT) is activated to status the launch countdown and address any issues remaining from the FRR.

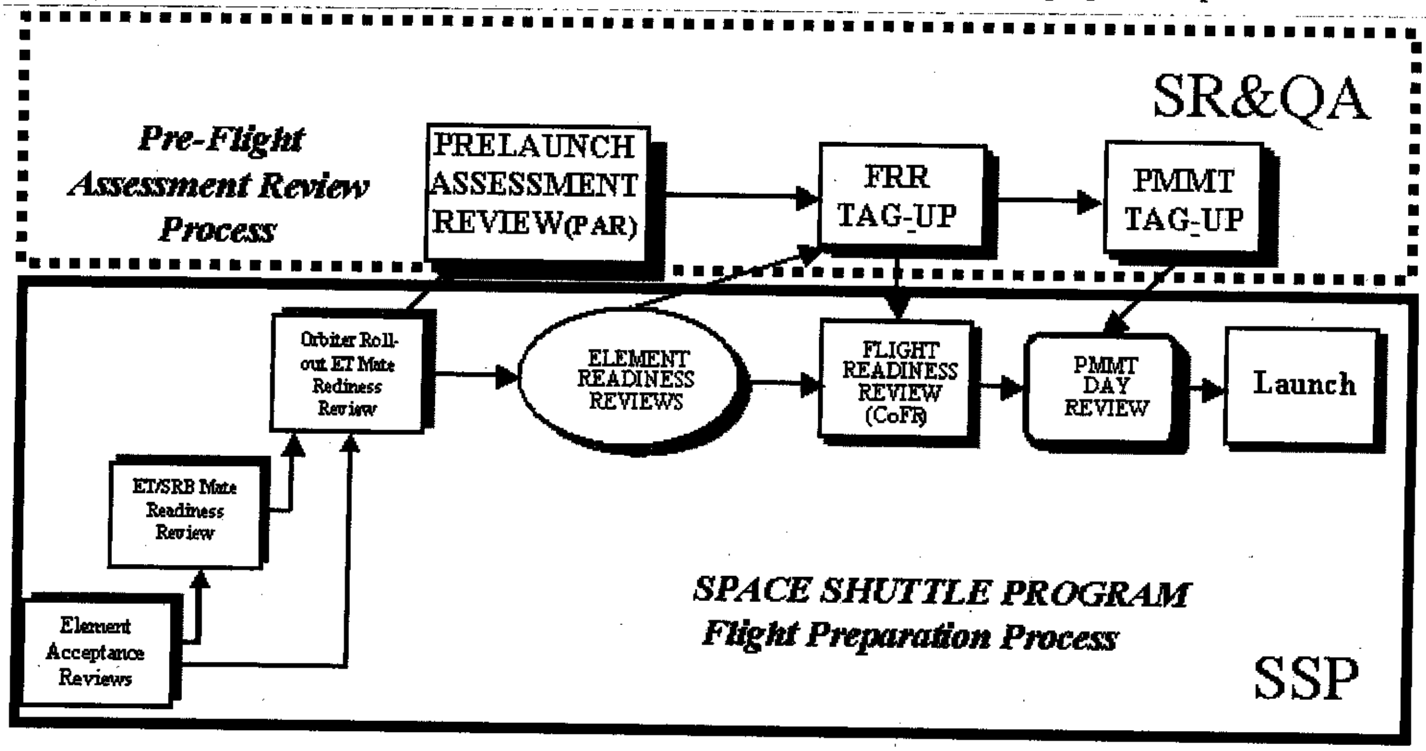
Figure 1, Milestone Reviews Process



In addition to the COFR process, the Safety, Reliability, and Quality Assurance (SR&QA) organization conducts a Pre-Flight Assessment Review (PAR) process for each space shuttle flight. The PAR process focuses specifically on assessing safety of flight issues and mission assurance issues. Examples of data that are assessed includes:

- Hazard Analysis
- Launch Commit Criteria
- NASA Safety Reporting System (NSRS)
- Flight Rules/Crew Procedures
- Software
- FMEA/CIL
- Alerts system
- Hardware Problems
- Waivers/Deviations
- In-Flight Anomalies
- Operations and Maintenance RequirementsLimited Life
- Certification
- Configuration
- Significant Nonconformance
- Unexplained Anomalies
- Cannibalization
- Deferred Work
- Training
- Restricted Use Hardware

The following chart shows the in-parallel PAR process with the flight preparation process.



Attachment 2

Questions to be Addressed at the Joint House/Senate Shuttle Hearing on 2/12/03

1. How does the Administration plan to maintain the independence of the Columbia Accident Investigation Board when it reports to the NASA Administrator and is staffed by NASA personnel who may be subject to the investigation? (Code G)
2. Did any space transportation policies contribute to the Space Shuttle Columbia accident? (Code I with B)
3. What is the role of human space exploration vice other national priorities? (Code I)
4. With over 6,800 single point failures on the Space Shuttle, what is an acceptable level of risk that the nation is willing to accept in pursuit of human spaceflight activities? (Code Q lead with support of M)
    a. Was NASA's risk analysis for Shuttle safety (1 in 265 chance of failure) prior to the Columbia accident realistic?
5. What are NASA's plans to ensure the safety of the 3 astronauts? (Expedition Commander Ken Bowersox, Nikolai Budarin and Don Pettit) (Code M)
6. Did NASA compromise Space Shuttle safety by focusing too much on short-term planning while constraining the Space Shuttle budget over the last 10 years? (Code M)
7. Will NASA accelerate its Space Shuttle Life Extension Program of safety and supportability upgrades in light of the Columbia accident? (Code M)
8. Did NASA workforce reductions on the Space Shuttle program (from 3,000 to 1,800 full time employee reductions between FY1995-99) heighten risks to the Space Shuttle fleet? (Code M lead with support from Code Q)
9. Should the U.S. re-evaluate its current dependency on the Space Shuttle and Russian Soyuz/Progress vehicles as the only means of transportation to the International Space Station and accelerate alternative means for human spaceflight transportation like Apollo-like capsules or NASA's Orbital Space Plane program? (Code R lead with support from Code M)
10. Did past failures to develop the next generation human spaceflight transportation system detract from necessary safety upgrades to the current Space Shuttle fleet? (Code M)
11. Did budget cuts to the Space Shuttle program over the last 10 years contribute to systemic safety problems with the Space Shuttle? (Code M lead with support from Code Q)
12. Are additional resources necessary in the short-term to insure the safety of the 3 astronauts currently on board the ISS? (Code M)
13. Are additional resources necessary for the Space Shuttle Life Extension Program safety and supportability upgrades on the Space Shuttle fleet or for the next generation human spaceflight transportation system? (Code M)

14. Did NASA have adequate resources during launch and during Columbia's 16 day mission to investigate damage that might have been caused to Columbia's heat resistant tiles from the External Tank foam that fell during launch? (Code M)
15. Was there any recourse for the Columbia crew is a major problem on the left wing's thermal protection system was identified? (Code M)
    a. Why was the Columbia mission planned for a different orbit than the ISS when the ISS could serve as a way-station in case of problems?
    b. Could the Columbia pilot have re-entered Earth's atmosphere in a way that would have "favored" the damaged left wing, as was reportedly done during an Atlantis mission in May 2002?
    c. Could Columbia have remained in orbit long enough for an emergency Space Shuttle recovery of the crew?
16. Were any safety procedures short–changed in the Space Shuttle program as a result of budget cuts over the last 10 years? (Code M lead with Code Q support)
17. How does NASA evaluate and act on safety recommendations for the Space Shuttle form its advisory groups and others? (Code M)
18. How does NASA evaluate safety recommendations from government and contractor safety engineers and technicians working directly on the program? (Code M)
19. In planning and during spaceflight operations, how does NASA internally communicate relevant safety information? (Code M)
20. With over 6,800 single point failures on the Space Shuttle, are there other safety measures beyond NASA's current upgrades program that should be pursued? (Code M)
21. Were any specific Space Shuttle safety-related technologies (e.g., crew escape module, thermal protection, etc.) curtailed due to lack of planning and funding? Did any of those curtailed measures contribute to the cause of the Space Shuttle Columbia accident? (Code M)
22. Are certain Space Shuttle safety-related technologies needed in the Shuttle fleet before returning to flight? (Code M)
23. Are certain Space Shuttle safety-related technologies needed to extend the life of the Space Shuttle program? (Code M)
24. What is the difference between the approach of the Rogers Commission and the approach laid out by NASA? (Code G)

6 February 2003

Guidelines for the Collection of Space Shuttle Materials by Public Service Personnel

Unless you are certain that the piece of debris is not hazardous, do not disturb it in any way. Contact the NASA Recovery Team Command Post or the on-site health and safety representative.

Do not attempt to recover pieces of Shuttle debris if they contain fibrous materials, could contain liquids or compressed gases, or could contain explosive devices. **Examples of these are: fuel tanks or cylinders, tubing, Shuttles tiles or other insulation.**

Small pieces of metal, electronics, and other Shuttle debris may be handled with a minimum of Personal Protective Equipment (PPE) such as leather gloves. Debris suspected of containing Shuttle fuels should be examined upwind at a distance. Under all circumstances, the disturbance of debris should be minimized to avoid creating airborne particulates. **Selection of proper protective clothing should be coordinated with the on-site health and safety representatives or incident commander on a daily basis.**

Collected debris should be put into a plastic bag or other sealed container. Appropriate control zones should be established to prevent exposure to unprotected personnel, since valves and pressurized vessels of Shuttle fuel systems are designed to fail closed. Assume all tubing and related items to be contaminated with hazardous Shuttle fuel.

Parts and materials contaminated with hazardous Shuttle fuels, that have been put into a bag or other closed container (such as a car trunk), may slowly off-gas in the bag or container used for storage. Caution should be used when opening vehicle doors, trunks, plastic bags, and other containers that are known or, suspected to have been, contaminated with hazardous Shuttle fuels.

Personnel should wash their hands, forearms, and face prior to eating, drinking, or smoking. Personnel should shower or change cloths prior to going home when possible.

BLI	COG	UPN	Sub Break 1	Sub Break 2	
38	925	372	00	00	Columbia Recovery and Investigation (STS-107)
			10	00	Recovery Support
				10	Program Effort
			20	00	Investigation Support
				10	External Tank
				20	SSME
				40	Ground Operations
				50	Reusable Solid Rocket Motor
				60	Solid Rocket Booster
				70	Vehicle Engineering/Orbiter
				80	Program Integration
				90	Program Management
			30	00	Institutional Support
				10	Recovery Effort
				20	Investigation Effort
				30	Center Support Other
			40	00	Special Flight Crew Ops
				10	Family Support
			50	00	Memorial
				10	JSC
				20	HQs

DATA REVIEW AND TIMELINE TEAM

February 10, 2003

Don McCormack/MV

Data from Rev 12 Master Timeline