

A RENEWED COMMITMENT TO EXCELLENCE

**AN ASSESSMENT
OF THE
NASA AGENCY-WIDE APPLICABILITY
OF THE
COLUMBIA ACCIDENT INVESTIGATION BOARD
REPORT**

JANUARY 30, 2004



The NASA Vision

To improve life here,
To extend life to there,
To find life beyond.

The NASA Mission

To understand and protect our home planet,
To explore the universe and search for life,
To inspire the next generation of explorers
...as only NASA can.



PREFACE

February 1, 2003 was a turning point in the history of NASA. There had been accidents before the loss of Shuttle *Columbia* and its crew, and there had been Agency reviews, both internal and external. Although these prior accidents and subsequent investigations provided NASA opportunities to learn and evolve, the *Columbia* accident made it painfully clear that NASA's safety and reliability performance was still falling short. What was lost that day were not only seven lives and an historic spacecraft, but also the confidence that NASA knew how to identify problems and resolve them properly.

The Columbia Accident Investigation Board (CAIB) was established within hours of the Shuttle's loss, and the Board proceeded to work independently and thoroughly to figure out what went wrong. Accident investigators traditionally include a determination of "probable cause" in their reports, but the CAIB Report has two causal statements, one "physical," the other "organizational." The physical causes are the Sequence of events on Shuttle Mission STS-107 that destroyed the Orbiter; the organizational causes are the failures within NASA that allowed those events to occur.

The CAIB released its Report in August 2003, followed by five volumes of appendix material in October, and with that the Board's work was concluded. But the job for NASA was just beginning. In the months following the loss of *Columbia* and her crew, the Agency had been making both technical and procedural changes, based on its own examination of the accident and on interim recommendations from the CAIB. Once the investigation Report was made public, those efforts accelerated.

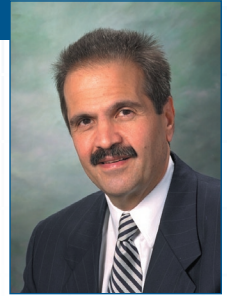
The NASA Administrator Sean O'Keefe chartered an executive team, which came to be known as the Diaz Team, and gave it the assignment of identifying those CAIB Report elements with Agency-wide applicability and developing measures to address each one. What follows is the Report of that team. It should be noted that while the Team focused on the organizational causes described in the CAIB Report which were related to NASA's culture, the Team did not do a broad, in-depth assessment of the cultural changes needed to address the organizational causes. The Team focused specifically on the CAIB Report and those Recommendations, Observations, and Findings (R-O-Fs) that had broad Agency-wide application beyond the Human Space Flight Program. Admittedly, some of the actions recommended

by the Team are actions one would expect to see an organization take if it were trying to change its culture, but the goals offered by the Team are intended as only a first step in the process.

Had the fate of STS-107 been the result of a small number of well-defined problems in a single program, finding solutions would be a relatively straightforward matter. But the CAIB determined that such is not the case. It was their conclusion that the mistakes made on STS-107 were not isolated failures, but rather were indicative of systemic flaws that existed prior to the accident. The Diaz Team believes that some of these systemic flaws exist beyond the Shuttle Program. It was our determination that nearly half of the CAIB R-O-Fs have bearing throughout the Agency.

All the selected R-O-Fs were compiled and analyzed in what the Team called the CAIB Agency-wide Action Matrix, or Diaz Team Matrix. We felt it was very important to release an early draft of the matrix to facilitate discussions within NASA. In response, there were many inputs from NASA employees and contractors during Safety and Mission Success Week, November 17 – 21, 2003. The message from this activity is clear. Individuals in the NASA workforce state that some of the same practices identified by the CAIB are evident throughout the Agency.

If NASA is to avoid another day like February 1, 2003, we must meet our mission objectives safely and renew our commitment to excellence. In order to do this, we must identify corrective actions for each of the causes of the accident, and then implement them fully and effectively. The CAIB Report should serve as a catalyst for change in the way all of us perform our work. It should prompt a renewed understanding of our shared purpose. Each member of this Team has recognized these high stakes and has dedicated his or her efforts to that end. The signatures on this Report and the participation of each member of the NASA leadership team at NASA Headquarters as well as at each of the NASA field Centers are a reflection of our joint commitment to NASA's future.



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ACKNOWLEDGEMENTS

The Diaz Team would like to thank each Center Director and each NASA Headquarters Associate and Assistant Administrator and their staff for their support and valuable feedback. In addition, our sincere thanks go to each NASA employee and contractor who participated in discussions and provided their insights especially through participation in Safety and Mission Success Week, November 17 – 21, 2003. Those contributions were of great value, and they have been incorporated into this final Report. In that respect, therefore, this is their Report, as well as ours.

We would like to give special acknowledgement to the One NASA Team led by Mr. Johnny Stephenson. Their energy and dedication to NASA was instrumental in achieving the success of Safety and Mission Success Week.

While it is difficult to acknowledge each individual that made a significant contribution to the development of this Report, there are two individuals that deserve special recognition. The Team would like to thank Ms. Judy Bruner, Assistant Director for Safety and Security, NASA's Goddard Space Flight Center, for her steadfast commitment and dedication to the successful development of this Report and for her personal contributions to its content. We would also like to recognize the invaluable contributions of Mr. Kevin Mabie, Valador Inc., for his contributions both in writing as well as producing this Report.

DEDICATION

The Diaz Team would like to dedicate this Report and the efforts involved in the development of it to the memory of the crew of the Space Shuttle *Columbia*. It was their bravery that inspired us to make a difference in NASA's future on their behalf.

A handwritten signature in black ink, appearing to read "Al Diaz".

Mr. Al Diaz
*Director, Goddard Space Flight Center
and Team Lead*



Preface	1
Acknowledgements and Dedication	2
1.0 Executive Summary	5
1.1 Introduction	5
1.2 Leadership	10
1.3 Learning	11
1.4 Communication	12
1.5 Processes and Rules	13
1.6 Technical Capabilities	14
1.7 Organizational Structure	15
1.8 Risk Management	16
1.9 Summary	17
1.10 Next Steps	17
2.0 Introduction	19
2.1 Background	19
2.2 The Team and Its Charter	19
2.3 R-O-F Categories	19
2.4 Team Discussions	19
2.5 Safety and Mission Success Week	20
2.6 Report Layout	21
3.0 Leadership	22
3.1 Introduction	22
3.2 Category R-O-F Summary	22
3.3 Discussion	22
4.0 Learning	26
4.1 Introduction	26
4.2 Category R-O-F Summary	26
4.3 Discussion	26
5.0 Communication	30
5.1 Introduction	30
5.2 Category R-O-F Summary	30
5.3 Discussion	30
6.0 Processes and Rules	34
6.1 Introduction	34
6.2 Category R-O-F Summary	34
6.3 Discussion	34
7.0 Technical Capabilities	38
7.1 Introduction	38
7.2 Category R-O-F Summary	38
7.3 Discussion	38
8.0 Organizational Structure	42
8.1 Introduction	42
8.2 Category R-O-F Summary	42
8.3 Discussion	42
9.0 Risk Management	46
9.1 Introduction	46
9.2 Category R-O-F Summary	46
9.3 Discussion	46
10.0 Summary and Next Steps	50
10.1 Summary	50
10.2 Next Steps	A-1
Appendix A The Diaz Team Matrix	A-1
Appendix B Acronyms	B-1



List of Tables

Table 1.	The Physical Cause and Organizational Cause of the Columbia accident as determined by the CAIB.	5
Table 2.	The Diaz Team developed one goal for Leadership.	10
Table 3.	The Diaz Team developed one goal for Learning.	11
Table 4.	The Diaz Team developed one goal for Communication.	12
Table 5.	The Diaz Team developed one goal for Processes and Rules.	13
Table 6.	The Diaz Team developed one goal for Technical Capabilities.	14
Table 7.	The Diaz Team developed one goal for Organizational Structure.	15
Table 8.	The Diaz Team developed one goal for Risk Management.	16
Table 9.	Organizing the R-O-Fs – the seven categories and their definitions.	20
Table 10.	The Diaz Team developed one goal for Leadership.	24
Table 11.	The Diaz Team determined that three Observations, and 14 Findings could be included in the Leadership Category resulting in seven actions.	25
Table 12.	The Diaz Team developed one goal for Learning.	28
Table 13.	The Diaz Team determined that one Recommendation and four Findings could be included in the Learning Category resulting in three actions.	29
Table 14.	The Diaz Team developed one goal for Communication.	32
Table 15.	The Diaz Team determined that five Findings could be included in the Communication Category resulting in two actions.	32
Table 16.	The Diaz Team developed one goal for Processes and Rules.	36
Table 17.	The Diaz Team determined that two Recommendations, three Observations, and six Findings could be included in the Processes & Rules Category resulting in seven actions.	36
Table 18.	The Diaz Team developed one goal for Technical Capabilities.	40
Table 19.	The Diaz Team determined that three Recommendations, and 13 Findings could be included in the Technical Capabilities Category resulting in six actions.	40
Table 20.	The Diaz Team developed one goal for Organizational Structure.	44
Table 21.	The Diaz Team determined that three Recommendations and 10 Findings could be included in the Organizational Structure Category, resulting in four actions.	45
Table 22.	The Diaz Team developed one goal for Risk Management.	48
Table 23.	The Diaz Team determined that four Recommendations, two Observations, and 12 Findings could be included in the Risk Management Category resulting in 11 actions.	49
Table 24.	Diaz Team Goals	50

List of Figures

Figure 1.	The Diaz Team process required wide acceptance and dissemination of all determinations.	6
Figure 2.	Diaz Team determination of broadly applicable R-O-Fs for the Agency.	7
Figure 3.	Seven NASA organizations have actions resulting from the Diaz determinations.	7
Figure 4.	Overlap currently exists between the Implementation Plans for different organizations. NASA Headquarters must coordinate when duplications of efforts might occur.	8
Figure 5.	The Diaz Team categorized the CAIB R-O-Fs into seven distinct categories, each of which has a major premise. Each category is fully addressed in the body of the Report.	9



1.0 EXECUTIVE SUMMARY

The Diaz Team's Charter:

- Identify those R-O-Fs from the CAIB Report that might apply across the Agency.
- Identify a set of actions and suggested leadership for those actions.
- Include the One NASA* Team in all activities.
- Summarize results in a Report to the NASA Deputy Administrator.

1.1 INTRODUCTION

The Space Shuttle fleet has been grounded since the *Columbia* accident. As a result, "Return to Flight" has become not just a phrase but a program, and the goal of virtually everyone associated with NASA. Even those who are not affiliated with the Shuttle Program are looking forward to the safe and successful completion of the next Shuttle mission. In this recovery process, NASA will be guided by the Report of the Columbia Accident Investigation Board (CAIB).

The CAIB was an investigating body, convened by NASA Administrator O'Keefe the day of the *Columbia* accident, according to procedures established after the loss of Shuttle *Challenger*. The 13 Board Members and more than 120 staff members examined more than 30,000 documents, conducted more than 200 formal interviews, heard testimony from dozens of expert witnesses, and reviewed more than 3,000 public inputs. While the CAIB maintained strict independence from NASA in its deliberations and analysis, it did receive technical support from approximately 400 NASA engineers. In addition, more than 25,000 searchers helped retrieve the *Columbia* debris.

The CAIB ultimately drew a distinction between the physical and organizational causes of the accident, and the Board Report accordingly included separate causal statements. The physical cause statement documented the sequence of events on Shuttle

Mission STS-107 that led to the breakup of the Orbiter. A variety of separate analyses, each based on its own extensive body of evidence, all pointed to the sequence found in that causal statement of the CAIB Report. The organizational cause statement spells out what might be considered the precursors to the physical cause: the conditions that allowed the technical failures to take place and eventually lead to the accident. Table 1 contains the Physical Cause Statement and Organizational Cause Statement.

Of the 29 recommendations in the Report of the CAIB, 15 are designated as "RTF" signifying that they must be completed before the Space Shuttle can "Return to Flight." But the CAIB recognized, and NASA Administrator Sean O'Keefe has concurred, that the problems at NASA extend beyond what is addressed in those 15 recommendations. That is why the CAIB Report contains 14 more recommendations, as well as 27 observations and 137 findings. Most of these are specific to the long-term operation of the Human Space Flight Program, but the Administrator recognized that a substantial number might be applied across the Agency. Taking these necessary prescribed steps will ensure, in the opinion of the Diaz Team, that not only will the Shuttle "Return to Flight," but all of NASA will renew its commitment to excellence.

Which are the recommendations, observations, and findings (R-O-Fs) that have this broad applicability Agency-wide? That is the question that NASA's Administrator put to a team comprised

Table 1. The Physical Cause and Organizational Cause of the Columbia accident as determined by the CAIB.

Physical Cause and Organizational Cause
<p>CAIB Report Chapter 3, p49: <i>The physical cause of the loss of Columbia and its crew was a breach in the Thermal Protection System on the leading edge of the left wing. The breach was initiated by a piece of insulating foam that separated from the left bipod ramp of the External Tank and struck the wing in the vicinity of the lower half of Reinforced Carbon-Carbon panel 8 at 81.9 seconds after launch. During re-entry, this breach in the Thermal Protection System allowed superheated air to penetrate the leading-edge insulation and progressively melt the aluminum structure of the left wing, resulting in a weakening of the structure until increasing aerodynamic forces caused loss of control, failure of the wing, and breakup of the Orbiter.</i></p> <p>CAIB Report Chapter 7, p177: <i>The organizational causes of this accident are rooted in the Space Shuttle Program's history and culture, including the original compromises that were required to gain approval for the Shuttle Program, subsequent years of resource constraints, fluctuating priorities, schedule pressures, mischaracterizations of the Shuttle as operational rather than developmental, and lack of an agreed national vision. Cultural traits and organizational practices detrimental to safety were allowed to develop, including: reliance on past success as a substitute for sound engineering practices (such as testing to understand why systems were not performing in accordance with requirements/specifications); organizational barriers that prevented effective communication of critical safety information and stifled professional differences of opinion; lack of integrated management across program elements; and the evolution of an informal chain of command and decision-making processes that operated outside the organization's rules.</i></p>

* The One NASA effort was initiated prior to the *Columbia* accident by a group of middle managers from across the Agency. The vision of One NASA is for a more cohesive, collaborative, and less bureaucratic Agency.



of members of NASA’s Senior Leadership Council led by Mr. Al Diaz, Director of the Goddard Space Flight Center. It has also been their assignment to spell out a specific course of actions to accomplish what has been called for. Other members of what has come to be called the Diaz Team include: Dr. Ghassem Asrar, Associate Administrator for Earth Sciences, NASA Headquarters; Dr. Julian Earls, Director, Glenn Research Center; Mr. Scott Hubbard, Director, Ames Research Center; Mr. James Kennedy, Director, Kennedy Space Center; and Ms. Vicki Novak, Assistant Administrator for Human Resources, NASA Headquarters.

The Organizational Cause Statement in the CAIB Report guided the Team’s deliberations from the beginning. The Team, therefore, determined that all R-O-Fs that dealt directly or indirectly with organizational behaviors that might have a bearing on safety or mission success would be identified as having Agency-wide applicability. In addition, the Team has worked to assure that its Report would be understood and accepted by the NASA workforce. With that objective in mind, the Team established a work plan at its first meeting in September 2003 that allowed for extensive Agency review of all that the Team produced. Figure 1 outlines that plan. The first product the Diaz Team developed and distributed was the CAIB Agency Wide Action Matrix, hereafter referred to as the Diaz Team Matrix, which is included as an appendix in the Report. The Diaz Team Matrix is in a tabular format that identifies which R-O-Fs are broadly applicable. The entry for each R-O-F provides a rationale for including it and recommends a set of actions to address it. The Diaz Team Matrix went through a series of reviews, first by Diaz Team members, and then by NASA senior management. To facilitate discussions during Safety and Mission Success Week, the matrix was then distributed to more than 65,000 members of the NASA workforce, both civil service and

contractor employees. The resulting feedback was outstanding in both quantity and quality. A thorough review of those many thoughtful comments showed that an overwhelming majority served to validate both the CAIB evaluation of NASA and the Diaz Team Matrix. With the help of the One NASA Team, the Diaz Team organized the Agency-wide feedback and the Diaz Team Matrix itself into distinct categories, which is discussed throughout the Report.

The Team identified 85 R-O-Fs that it determined to have Agency-wide applicability. (See Figure 2.) The Team developed 40 “Specific Actions” for NASA to take in order to meet the requirements contained in those R-O-Fs. Each action consists of multiple tasks and requires a detailed implementation plan. Each action has been assigned a NASA Headquarters code, signifying which organization has primary responsibility for implementing that action. Figure 3 shows the distribution of the actions across seven Headquarters organizations.

In addition, the Team has identified a limited number of “Diaz Team Goals.” Given the broad nature of these goals, the Diaz Team has not made a specific suggestion with respect to assigning responsibility for their implementation. However, it is expected that the Agency would respond to these goals in subsequent planning.

Beyond these 85 R-O-Fs, it was recognized that while the remaining elements might not have Agency-wide applicability, they might have applicability outside the Human Space Flight Program and therefore should not be overlooked. Individual organizations may very well find that some have bearing on their projects. This will be especially true for programs that conduct aircraft operations or support development of new aerospace

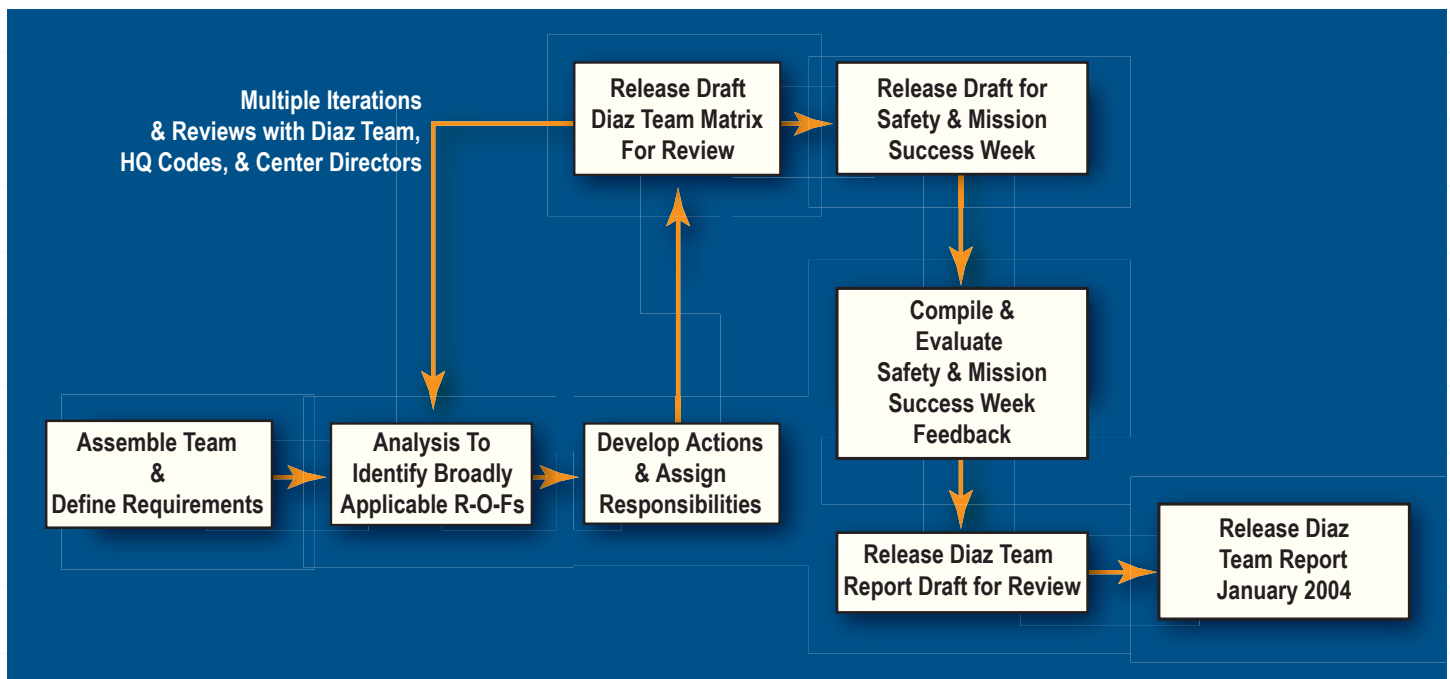


Figure 1. The Diaz Team process required wide acceptance and dissemination of all determinations.

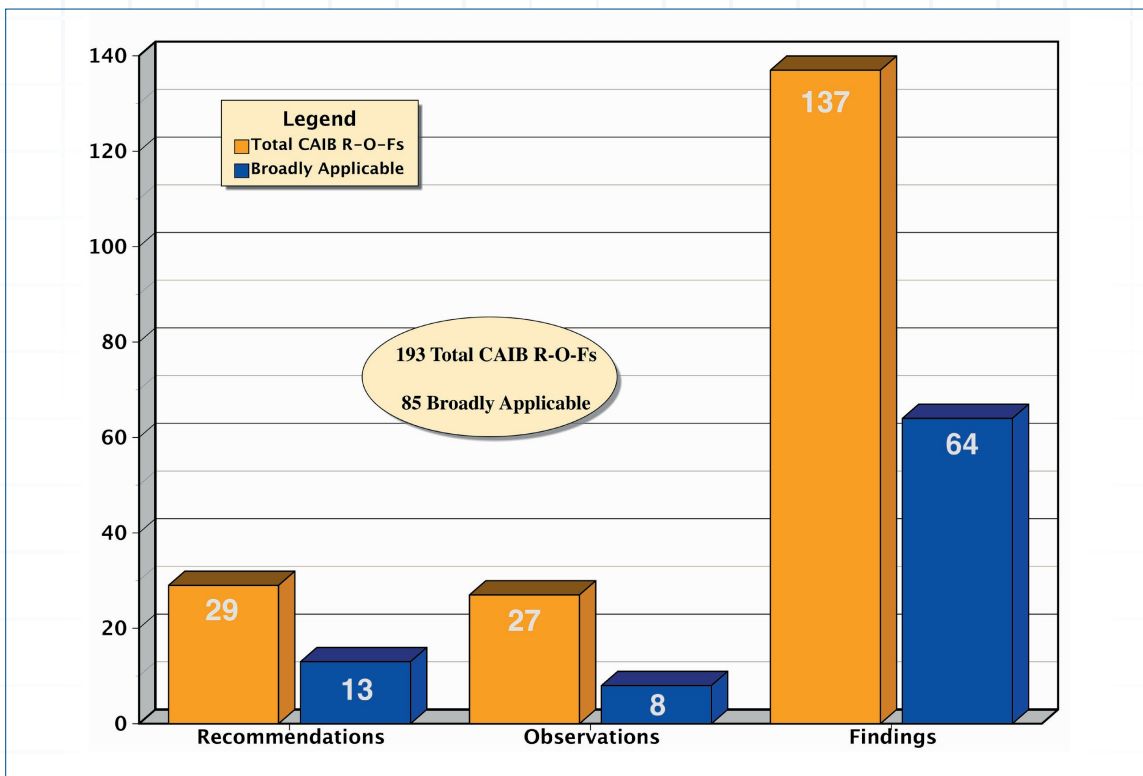


Figure 2. Diaz Team determination of broadly applicable R-O-Fs for the Agency.

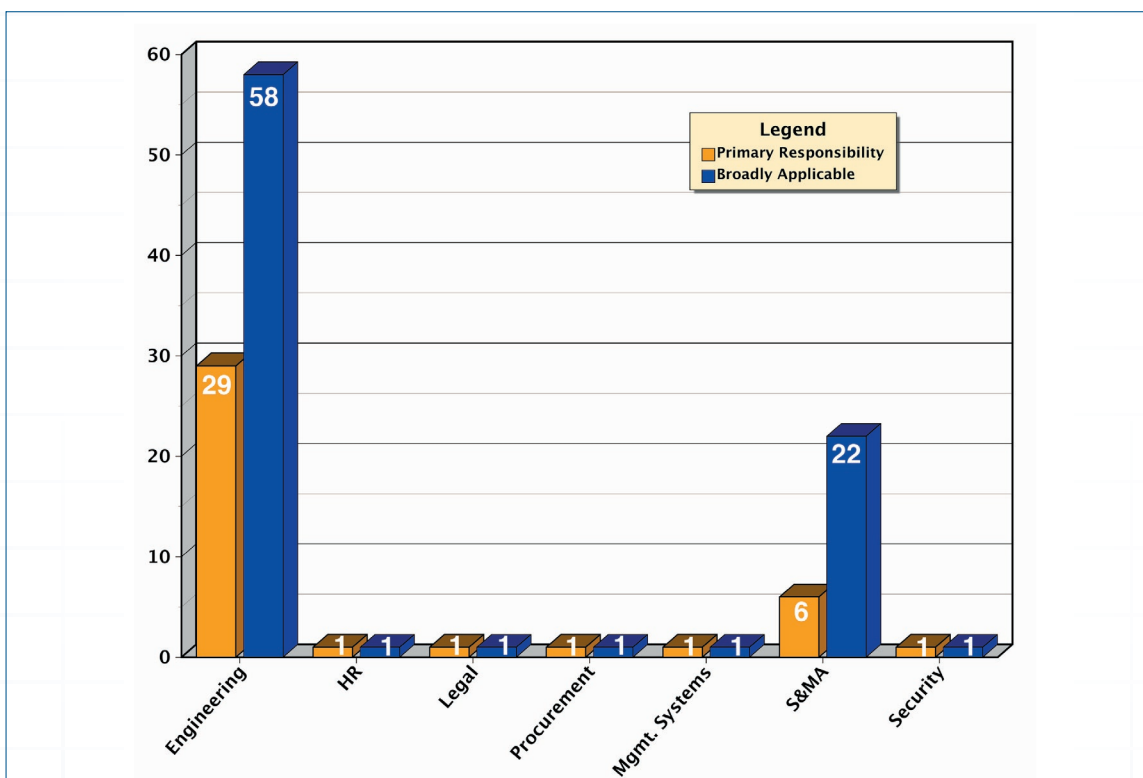


Figure 3. Seven NASA organizations have actions resulting from the Diaz determinations.

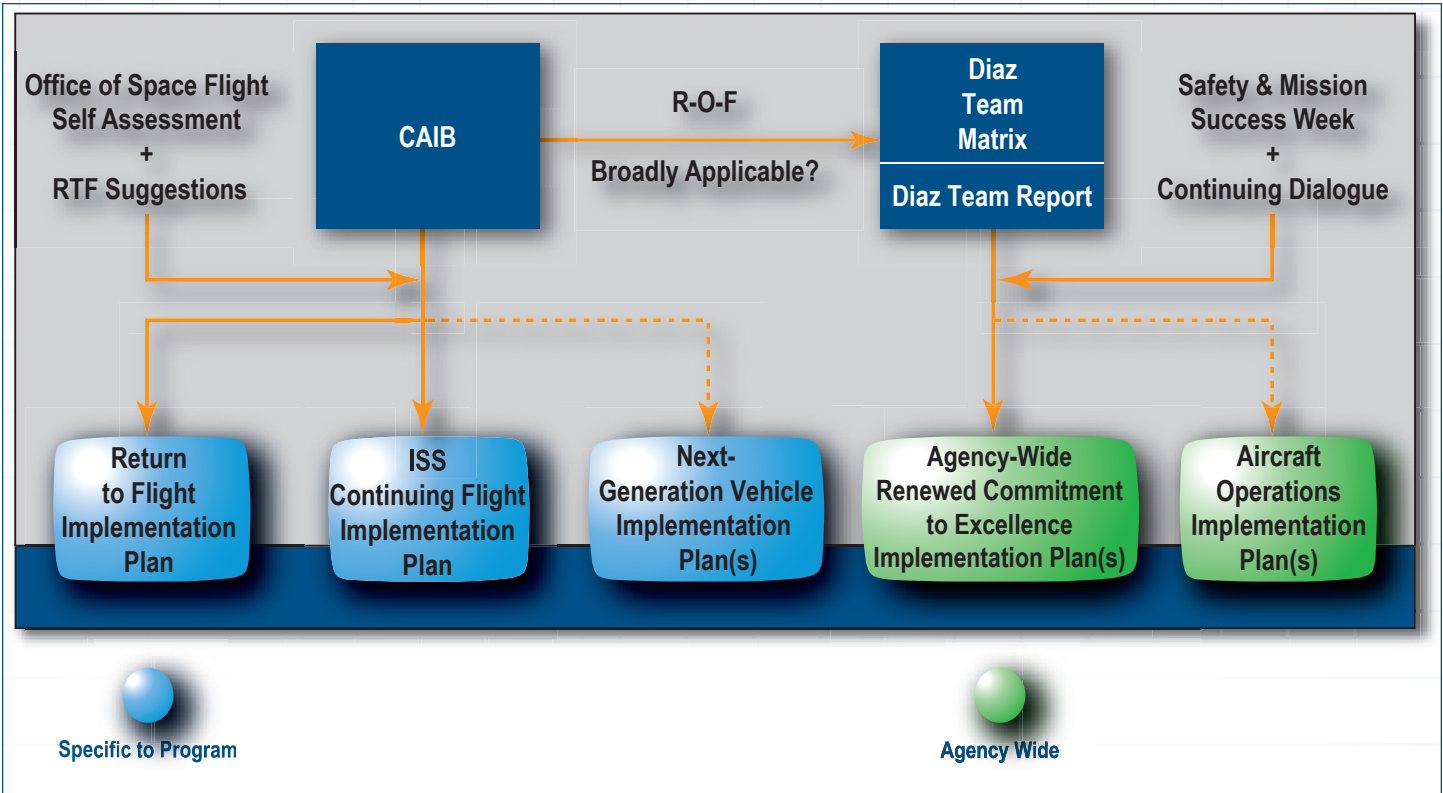


Figure 4. Overlap currently exists between the Implementation Plans for different organizations. NASA Headquarters must coordinate when duplications of efforts might occur.

vehicles such as the Next-Generation Vehicle or next-generation launch technologies. The Team encourages these organizations to address the additional R-O-Fs in the same way that the Diaz Team, Return to Flight (RTF) Team, and Continuing Flight Team (CFT) have done. These teams have each developed implementation plans to address the CAIB R-O-Fs. Since these plans have overlapping actions that address each R-O-F, it will be important for NASA Headquarters to coordinate these activities. Figure 4 shows how these plans relate to each other. Specific expectations with respect to the development of the Renewed Commitment to Excellence Implementation Plan(s) are discussed in “Next Steps,” Section 1.9.

The Safety and Mission Success Week provided the Diaz Team with a valuable opportunity to engage the NASA workforce in its deliberations. The free exchange of views about problems and proposed solutions validated the thesis that the CAIB Report had broad applicability across NASA and specifically the Team’s approach for addressing the R-O-Fs. The Diaz Team Report uses statements that are derived from Safety and Mission Success Week feedback to confirm the Team’s assessments of the R-O-Fs, and the corresponding recommended actions.

Rather than maintain all 85 R-O-Fs as a single large group, the Diaz Team found arranging and presenting them in categories could utilize them most effectively. After extensive analysis of the NASA workforce inputs from Safety and Mission Success Week, the comments received were grouped into seven categories:

- Leadership
- Learning
- Communication
- Processes & Rules
- Technical Capabilities
- Organizational Structure
- Risk Management

Each category is described in more detail throughout the Report, including the Diaz Team’s conclusions about the R-O-Fs in that category. Each of the seven sections discussing the categories has a summary that follows the approach shown in Figure 5.

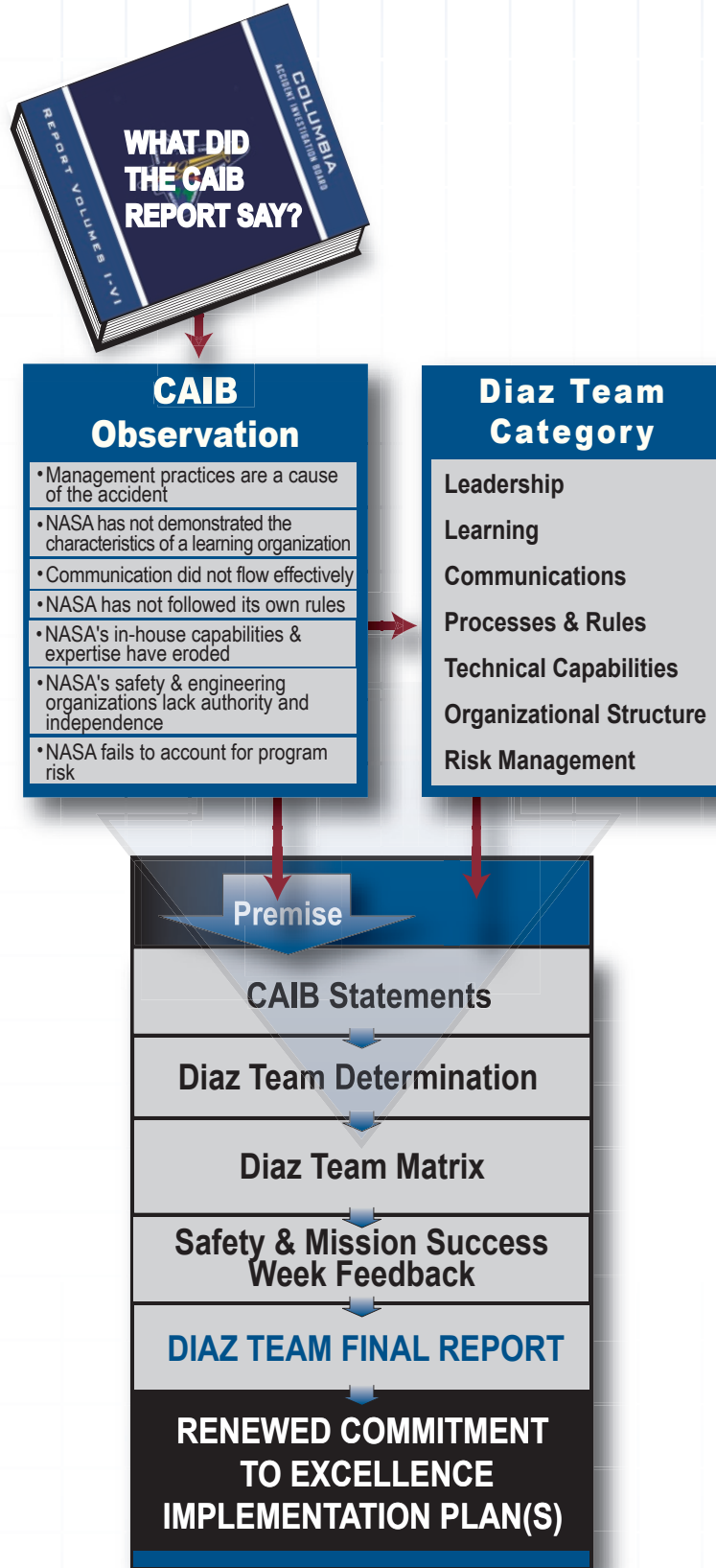


Figure 5. The Diaz Team categorized the CAIB R-O-Fs into seven distinct categories, each of which has a major premise. Each category is fully addressed in the body of the Report.



1.2 LEADERSHIP



CAIB Report Chapter 8, p203:

Leaders create culture. It is their responsibility to change it. Top administrators must take responsibility for risk, failure, and safety by remaining alert to the effects their decisions have on the system. Leaders are responsible for establishing the conditions that lead to their subordinates' successes or failures.

Management practices are a cause of the accident.

Agency-wide Themes

- Leaders must lead by example, creating conditions and a culture for safety and mission success.
- Leaders must balance schedule and risk.
- Leaders should allow and encourage diversity of views, eliminate retribution towards those with differing opinions, and understand that "No" is an acceptable answer.
- Leaders should be grown throughout all levels of the organization, through succession planning and developmental experiences.

NASA has a strong heritage for developing leaders at all levels of the Agency who have a "can-do" attitude. They have brought our Nation to the Moon and back, launched and managed hundreds of safe and successful human and unmanned missions to space, led us through seemingly hopeless situations like Apollo 13, and begun the complex construction and operation of the International Space Station. However, with the seriousness of the *Columbia* accident and the CAIB Report, NASA leaders need to reflect upon and grow from the lessons learned.

The CAIB Report had this to say about NASA's Leadership:

Post-Challenger policy decisions made by the White House, Congress, and NASA leadership resulted in the Agency reproducing many of the failings identified by the Rogers Commission. Policy constraints affected the Shuttle Program's organization culture, its structure, and the structure of the safety system. The three combined to keep NASA on its slippery slope toward *Challenger* and *Columbia*. (CAIB Report, Chapter 8, p. 197)

The Diaz Team's actions contained in the Diaz Team Matrix require that everyone understand their responsibilities and are given the authority to perform their jobs, with the accountability for their individual and program's successes and failures, including lessons learned. Leadership means making informed decisions and treating staff and contractor support with respect and courtesy to ensure that everyone understands their inputs are valued and important. It also involves empowering and developing the workforce, listening and communicating with them more effectively, and developing future leaders through progressive leadership development and effective organization succession

Table 2. The Diaz Team developed one goal for Leadership.

Leadership – Diaz Team Goal

The Agency should assess whether program management and budget formulation processes are adequate to assure there is an appropriate balance of requirements, resources, and risk to ensure safety and mission success.

planning and practices. Leadership means creating a climate and conditions for NASA employees and organizations to achieve safety and mission success.

The criteria used to delineate those R-O-Fs that were applied to leadership included the Agency-wide themes and a leader's ability to make and support decisions. These criteria address:

- Empowerment by understanding and communicating responsibility, accountability, and authority.
- Serving as an example and role model to employees by understanding and following the rules (but not "blindly"), and having a willingness to challenge the rules when safety and mission success are at stake.
- A willingness and ability to challenge schedules when appropriate and necessary based upon well thought-out and presented analyses of risks.
- Respect of others and fostering fair consideration of all points of view.

The feedback from Safety and Mission Success Week reinforced the Diaz Team assessments.

- » We need to make sure every voice is heard without fear of retaliation or suppression.
- » NASA leadership has become preoccupied by actions to address symptoms; we need the resources and leadership commitment to fix underlying causes.
- » We need to stress among NASA leadership the importance of responding to even the lowest level question. This was exactly why NASA did not exercise additional techniques with *Columbia* to research the problem.

Every member of the workforce must know his or her position in the organization; all must know their authority, responsibility, and accountability. The Diaz Team came to believe that at the root of some of the CAIB observations and individual comments was a concern about leadership's ability to determine whether there was an appropriate balance between requirements and resources allocated to their achievement. The Diaz Team goal on Leadership was developed in response to that concern. For this goal to succeed, changes discussed in other sections of the Report must also be pursued.

In addition to the actions in the Diaz Team Matrix that address each R-O-F, the Diaz Team has one goal addressing the Leadership category, as shown in Table 2.



1.3 LEARNING



CAIB Report Chapter 7, p192:

The Board concludes that NASA's current organization does not provide effective checks-and-balances, does not have an independent safety program, and has not demonstrated the characteristics of a learning organization.

NASA has not demonstrated the characteristics of a learning organization.

Agency-wide Themes

- NASA should provide robust simulation and emergency response training.
- Tools, databases, and models should be developed and used appropriately.

Much was said in the CAIB Report about the NASA culture and how its attributes contributed to the *Columbia* accident. The CAIB concluded NASA “has not demonstrated the characteristics of a learning organization” after investigators observed mistakes being repeated and lessons from the past apparently being relearned. The CAIB provided NASA with a number of recommendations and findings that could help it achieve the beneficial traits of a learning organization.

It is recognized there are efforts underway in NASA to address knowledge capture, management, and dissemination. These actions are in response to the concern for the impending retirement of a large segment of the NASA workforce. But more needs to be done to understand what the knowledge architecture in NASA is so that steps can be taken to preserve it. NASA needs a robust infrastructure to support all aspects of decision-making and knowledge management. The CAIB Report said that NASA has “dysfunctional databases.” Since NASA has a geographically dispersed organization consisting of a relatively small Headquarters with many Center facilities around the country, a suitable information storage and transfer system is essential to facilitate communication and learning. The CAIB had this to say:

In its investigation, the Board found that the information systems that support the Shuttle Program are extremely cumbersome and difficult to use in decision-making at any level. For obvious reasons, these shortcomings imperil the Shuttle Program’s ability to disseminate and share critical information among its many layers. (CAIB Report, Chapter 7, p. 189)

NASA personnel need to achieve a high level of technical and managerial competency along with a high state of readiness to deal with the research, developmental, and operational challenges inherent in the aerospace systems they manage and operate. In concert, the technical tools, information systems, and knowledge repositories of the Agency must be up to date and readily avail-

able to be used by personnel across the Agency. NASA can explore personnel training and learning through a variety of methods. More on-the-job training through apprenticeship programs and hands-on work can be emphasized for critical skills being lost at the Centers. In addition, comprehensive and systematic emergency response training simulating the work environment, as well as hands-on experience, are critical to creating a learning organization.

The feedback from Safety and Mission Success Week reinforced the Diaz Team assessment:

- » Mandate that current and new employees moving into management positions attend a lecture (sponsored by NASA) outlining historical lessons learned by NASA and comparable agencies. This lecture should be at least one day long and should cover lessons learned in several disasters (*Challenger, Columbia, Apollo 1, USS Thresher*) and close calls (i.e. *STS-93* and *Apollo 13*).
- » NASA should routinely run mock mishap investigations to root out its process, product, and programmatic weaknesses before a mishap actually happens.
- » NASA does not effectively transfer knowledge. NASA can significantly improve our knowledge management culture with lessons learned processes, trend analyses, transferring expert knowledge from people to systems, and portals that share information.
- » NASA should employ a more rigorous/disciplined acceptance testing & checkout procedure prior to placing any system (hardware or software) in operation. The requirements and results should be kept in a database with an independent group auditing input.

NASA can assure being a learning organization by:

1. Developing and using an Agency-wide knowledge management system to foster sound decision-making practices. Programs must have the ability to share information using central databases.
2. Requiring programs to have contingency and emergency response processes in place, and requiring the programs to conduct rigorous and ongoing training in those processes.

In addition to the actions in the Diaz Team Matrix that address each R-O-F, the Diaz Team has one goal addressing the Learning category, as shown in Table 3.

Table 3. The Diaz Team developed one goal for Learning.

Learning – Diaz Team Goal

The Agency should identify an appropriate approach for the future development of a knowledge management system and infrastructure to assure knowledge retention and lessons learned.



1.4 COMMUNICATION



CAIB Report Chapter 6, p170:

Management decisions made during Columbia's final flight reflect missed opportunities, blocked or ineffective communication channels, flawed analysis, and ineffective leadership. Perhaps most striking is the fact that management – including Shuttle Program, Mission Management Team, Mission Evaluation Room, and Flight Director and Mission Control – displayed no interest in understanding a problem and its implications.

Communication did not flow effectively.

Agency-wide Themes

- Anomalies should be considered problems until proven otherwise.
- Responsibility, authority, and accountability must be clearly understood and communicated.
- Communications need to flow both up and down the chain of command.
- Diverse viewpoints must be fostered and minority views considered.
- Communication practices must be validated and tested to ensure effective communication across NASA.

- » more analysis and testing. If the concerned person or organization cannot furnish data to prove a problem exists, no action will be taken.
- » One of the barriers that should be broken down is the communication barrier. The NASA workforce should feel comfortable to bring forward comments.
- » Why is it not OK to ask Why?
- » There is fear of reprisal for openly communicating dissenting opinions.
- » Most are reluctant to say anything for fear of criticism or they feel it isn't worth it. People have tried in the past to point things out but know it's not going to get them anywhere. NASA culture does not encourage or reward people who speak out.
- » There is a lack of a formal and effective structure to facilitate information flow up and down the management chain.

The CAIB Report discussed communication at all levels. The lack of effective communication from Headquarters to every member of the NASA workforce is a continuing problem, and was stressed in the Safety and Mission Success Week feedback. This is what the CAIB had to say about communication:

The organizational structure and hierarchy blocked effective communication of technical problems. Signals were over-looked, people were silenced, and useful information and dissenting views on technical issues did not surface at higher levels. (CAIB Report, Chapter 8, p. 201)

When broadly applied, the Diaz Team actions for Communication focus on developing a management and communication culture that is based on adequate discourse for anomaly resolution, a clear process for chain of command and contingency communication, and the codification of formal communication and reporting policies and procedures. This cultural change requires that NASA return to the process that considers anomalies as problems until proven otherwise. This philosophy, supported by a clear chain of command also supports contingency communication, or escalation paths, so that disagreements can be addressed to enhance anomaly resolution.

The feedback from Safety and Mission Success Week reinforced the Diaz Team assessment:

- » When concerns are raised, the prevailing attitude in NASA management is to require the concerned person or organization prove that something is a problem before action will be taken. The action may be just

The Safety and Mission Success feedback indicated a sense from some in the workforce that they have lost the ability to participate in the decision-making process. The feedback also suggests that there is a segment of the workforce with the desire to participate but who are afraid to do so. They are uncertain about their roles, and have a lack of understanding of the processes for dissent. In the Diaz Team's analysis of the Safety and Mission Success Week data, problematic communication was a recurring theme from Headquarters and every Center. Communication has a chance to improve when:

1. There is no fear of retribution.
2. Information is considered in an unbiased manner.
3. Every opinion is treated with respect.
4. Decision feedback is provided.

The CAIB findings and Diaz Team actions identify means to start building a more effective communication strategy. However, change in communication requires that leaders adopt different behavior and communication philosophies. Leaders should promote a diversity of viewpoints. Fear of retribution must be eliminated. The workforce needs a process to allow for dissenting opinion and intervention when retribution or retaliation is suspected. The new Agency Ombuds, recommended by the Diaz Team, should serve this purpose well.

In addition to the actions in the Diaz Team Matrix that address each R-O-F, the Diaz Team has one goal addressing the Communication category, as shown in Table 4.

Table 4. The Diaz Team developed one goal for Communication.

Communication – Diaz Team Goal

The Agency should continue the dialog that it began with the NASA workforce during Safety and Mission Success Week.



1.5 PROCESSES AND RULES



CAIB Report Chapter 8, p203:

When it came to managers' own actions, however, a different set of rules prevailed. The Board found that Mission Management Team decision-making operated outside the rules even as it held its engineers to a stifling protocol. Management was not able to recognize that in unprecedented conditions, when lives are on the line, flexibility and democratic process should take priority over bureaucratic response.

NASA has not followed its own rules.

Agency-wide Themes

- Requirements, policies, procedures, and directives must be examined and adhered to.
- Best practices and lessons learned must be incorporated.
- The entire workforce must be aware of and understand the rules.

Any complex organization must have processes and rules to conduct its business. NASA is no exception. In a complex government organization such as NASA, many policies, requirements, and procedures are developed for employees to follow in the conduct of programs, missions, designs, tests, and operations. Included in this category are the many processes for managing the external workforce of NASA through its large cadre of contractors. Many of these rules and processes were established as a result of adoption of best practices or lessons learned from program history. Some are the result of informal adoption into the culture of NASA – in essence – how NASA conducts its business. Others may be conflicting among organizations, outdated, or merely bureaucratic in nature offering little concrete benefit. The CAIB examined NASA's processes and rules closely as it related to the Shuttle accident and arrived at some key conclusions.

Throughout the CAIB Report, a recurring observation was that NASA did not follow its own rules. The Board discovered organizational practices detrimental to safety and reliability including the “evolution of an informal chain of command and decision-making processes that operated outside the organization's rules.” Yet, the Board believed rules which were followed within NASA were often more bureaucratic and had the effect of stifling critical communication.

After evaluating the CAIB Report and the Safety and Mission Success Week feedback, the Diaz Team has concluded that many in the workforce do not understand the policies and rules they are required to adhere to.

The CAIB Report had this to say about rules:

Cultural traits and organizational practices detrimental to safety were allowed to develop, including... lack of integrated management across program elements... and the evolution of an informal chain of command and decision-making processes that operated outside the organization's rules. (CAIB, Executive Summary, p. 9)

The way in which NASA develops and executes its rules and processes embodies a fundamental cultural trait for the Agency. Organizations that deal with high-risk technology must develop a best practices culture in order to operate safely and reliably. To achieve this within NASA, all programs must develop rules that lead to increased communication and enhanced decision-making.

The observations and findings of the CAIB also revealed a need for NASA to examine its processes, make changes where appropriate, and apply the processes uniformly across programs. The Board, in essence, stated that NASA must set required processes that ensure accurate and timely information flow and then “follow the rules” established for making decisions with this data. While many of the 40 actions in the Diaz Team Matrix require that the policies governing the R-O-F area be reviewed and modified if necessary, a complete review of policies and directives in the Agency should be conducted.

The feedback from Safety and Mission Success Week reinforced the Diaz Team assessment:

- » We say all the right language and have all the right procedures, but don't follow them.
- » When internal and contracted requirements are not firmly established, employees can feel that nothing is mandatory.
- » Crew Resource Management is a process used in other industries that can be applied across NASA and in particular mission-critical management positions.

In addition to the actions in the Diaz Team Matrix that address each R-O-F, the Diaz Team has one goal addressing the Processes and Rules category, as shown in Table 5.

Table 5. The Diaz Team developed one goal for Processes and Rules.

Processes and Rules – Diaz Team Goal

The Agency should conduct a review of its approach to maintaining and managing rules.



1.6 TECHNICAL CAPABILITIES



CAIB Report Chapter 7, p179:

As a result [of the Space Flight Operations Contract], experienced engineers changed jobs, NASA grew dependent on contractors for technical support, contract monitoring requirements increased, and positions were subsequently staffed by less experienced engineers who were placed in management roles. Collectively, this eroded NASA's in-house engineering and technical capabilities.

NASA's in-house capabilities and expertise have eroded.

Agency-wide Themes

- Analytical models and simulation tools must be used appropriately.
- NASA must address the loss of technical expertise due to retirement and outsourcing.
- Advanced technical capabilities must be developed.

NASA has always viewed itself as a cutting-edge technology organization, with accomplished scientists and engineers developing and applying the most modern of technology tools. During the investigation of the *Columbia* accident, the CAIB came to believe otherwise. There was evidence of erosion in NASA's technological capabilities and expertise within the Shuttle Program. The CAIB found problems with the use of modern tools and methods for information management. Research organizations today rely on modeling, simulation, design, and analytical tools. At NASA, the CAIB found ineffective and inconsistent access to these tools, along with cases of outright misuse. Some of this stemmed from a lack of technical understanding. The CAIB Report stated it this way:

As a result [of the Space Flight Operations Contract], experienced engineers changed jobs, NASA grew dependent on contractors for technical support, contract monitoring requirements increased, and positions were subsequently staffed by less experienced engineers who were placed in management roles. Collectively, this eroded NASA's in-house engineering and technical capabilities.... (CAIB Report, Chapter 7, p. 179)

Due to limited resources and current Agency operation philosophies, NASA has come to rely on contractors to perform engineering functions on its projects. In addition, downsizing without replenishment of critical skills over the past decade has further contributed to a skill imbalance that is liable to be exacerbated by future retirements. The above conditions, occurring across the entire Agency, has resulted in a decline in NASA's technical capabilities and competencies in its civil service workforce, and the over-reliance on developmental and operational contractors.

Table 6. The Diaz Team developed one goal for Technical Capabilities.

Technical Capabilities – Diaz Team Goal

The Agency should develop guidelines and metrics for assessing and maintaining its core competencies, including those associated with in-house work.

The theme of the two CAIB recommendations related to technical capabilities implies the Agency-wide need for technical capacity to maintain documentation and databases and the need to implement knowledge management practices and capabilities NASA-wide that are critical to technical management and decision-making. When evaluated from an Agency-wide perspective, it is clear that all NASA programs need validated models and analytical tools to assess the state of their systems and components. This will enable enhanced decision-making. Moreover, this implies a need to further develop technological competency within the Agency to effectively and consistently apply, maintain, and update these models and tools. One way to achieve this technological competency is to increase investment in the development and training of NASA's scientific and engineering workforce in order to increase their skill base and overall effectiveness.

The feedback from Safety and Mission Success Week reinforced the Diaz Team assessment:

- » Technical expertise is being lost within NASA due to retirement and the outsourcing of technical proficiency to contractors.
- » There is a need to have more decision-makers with hands-on experience in addition to theoretical knowledge.
- » Technical expertise needs improvement throughout NASA.
- » Technical tools and information systems are not there for people to effectively do their jobs.

NASA has taken steps recently to develop systems to identify critical competencies across the Agency. NASA should go further and develop strategies of continuous investment and practice for assuring that required competencies are maintained and applied to activities in an appropriate way. The future ability to make technically credible design, test, operational, and safety decisions will rely on NASA systematically improving its technical capabilities and competencies throughout the Agency.

In addition to the actions in the Diaz Team Matrix that address each R-O-F, the Diaz Team has one goal addressing the Technical Capabilities category, as shown in Table 6.



1.7 ORGANIZATIONAL STRUCTURE



CAIB Report Executive Summary, p9:

This report discusses the attributes of an organization that could more safely and reliably operate the inherently risky Space Shuttle, but does not provide a detailed organizational prescription. Among those attributes are: a robust and independent program technical authority that has complete control over specifications and requirements, and waivers to them; an independent safety assurance organization with line authority over all levels of safety oversight; and an organizational culture that reflects the best characteristics of a learning organization.

NASA's safety and engineering organizations lack authority and independence.

Agency-wide Themes

- NASA must ensure systematic checks-and-balances are in place.
- NASA must implement independent safety and technical organizations.
- Roles and responsibilities must be clearly defined and widely understood.

The Diaz Team felt strongly that changes suggested by the CAIB for the Space Shuttle Program were worth serious consideration throughout NASA. These changes were observed by the CAIB to be needed in NASA's organizational approach to allow for a healthy "check-and-balance" system to prevail.

The CAIB Report had the following to say about the need for such controls:

When high-risk technology is the product and lives are at stake, safety, oversight, and communication flows are critical. The Board found that the Shuttle Program's normal chain of command and matrix system did not perform a check-and-balance function on either foam or O-rings. (CAIB Report, Chapter 8, p. 198)

NASA must implement CAIB-suggested organizational structure changes. The current check-and-balance infrastructure is inadequate. The CAIB's answer to this issue was to create an Independent Technical Engineering Authority (ITEA) as a new key structural component within NASA for the Space Shuttle Program. The specific authority and responsibilities of that ITEA must be developed in accordance with the CAIB. However, the Diaz Team concluded that all programs would benefit from an independent engineering authority concept that is applied across the Agency, to ensure that technical standards are being met. Therefore, the Team recommends that an independent technical authority concept be applied on all technical programs. As recommended in the CAIB R7.5-1, the ITEA must, at a minimum: develop and maintain, and be the sole waiver-granting authority for all technical standards; conduct trend and risk analyses and own the failure mode, effects analyses, and hazard reporting sys-

tems; and decide what is and what is not an anomalous event. The feedback from Safety and Mission Success Week reinforced the Diaz Team assessment:

- » Have our leadership thoroughly evaluate the system of safety and mission success with regard to the plethora of organizations having responsibility for overseeing the safety and quality of work performed with the express intent of making it simpler, safer and higher quality/reliability while reducing the overlapping responsibilities.
- » Organizations must be structured to provide a more effective balance between program schedule/cost management and technical review authority.
- » NASA should look to eliminate or modify organizational distinctions that create divisions within the Agency, which potentially foster competition rather than collaboration.
- » Clearly define roles, responsibilities, and accountability starting with the role of the Agency/Center, then on down, to describe strategically what we want to do, who will do it, and who is responsible for what.

NASA should seriously consider CAIB-suggested organizational structure changes across the Agency. The organizational structure can help clarify roles and responsibilities of individual employees, work groups, and leadership. In transitioning to the new organization, every member of the workforce should be able to answer three basic questions:

- Do you know where you fit in the organizational structure?
- Do you know to whom you report, and who reports to you?
- Do you know your responsibility, authority, and accountability?

A healthy organizational structure is a solid foundation to help enable our people to succeed. NASA now has the opportunity to examine its organizational structure and redesign or create new organizational elements that are inherently healthier and succeed in creating the proper checks-and-balances and chains of accountability to enable effective communication and decision-making.

Table 7. The Diaz Team developed one goal for Organizational Structure.

Organizational Structure – Diaz Team Goal

The Agency should complete its current NASA-wide assessment and establish independent technical authority.