Independent
Assessment

NASA

Independent Assessment of the

Shuttle Processing Directorate

Engineering and Management Processes

Final Report

November 4, 1999

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Executive Summary

The team found that the Shuttle Processing Directorate workforce is highly dedicated and professional. Most staff members believe that the appropriate level of work was transitioned to the Space Flight Operations Contract (SFOC), United Space Alliance (USA) Ground Operations. The Shuttle Processing Directorate workforce has many responsibilities: NASA-retained tasks; on-going surveillance activities of the SFOC; review and approval of out-of-family disposition; Checkout and Launch Control System (CLCS) development and test; Shuttle upgrades assessments; Spaceport Technology Center efforts; NASA requirements (ISO 9001 registration, Voluntary Protection Program participation); and personnel development/training. The Shuttle Processing Directorate is doing more work with fewer resources than at any time in its history.

While everyone interviewed indicated that safety would not be compromised, those interviewed also indicated that the schedule could suffer and costs would most likely increase. Safety is the top priority. After safety, there is some uncertainty among the Shuttle Processing Directorate workforce as to whether development or surveillance is next in priority. In some cases, individuals determine the prioritization with no management guidance or intervention. The Shuttle Processing Directorate management team must reinforce as often as possible the tenet that safety is the top priority, and clearly state and document the priority of tasks.

Communications processes, both external and internal to the Shuttle Processing Directorate, are not as effective as needed. The Shuttle Processing Directorate management must continue face-to-face communications with Center and Shuttle program management to formulate requirements that will be imposed on the Shuttle Processing Directorate in the near- and long-term. Furthermore, the Shuttle Processing Directorate management should have additional, face-to-face interaction with the workforce to convey information.

To the Shuttle Processing Directorate management and workforce, the future poses difficult challenges. The uncertainty of the milestones for Shuttle privatization and commercialization makes strategic planning, workforce deployment, and prioritization difficult. The expectations of Space Shuttle program management, KSC management, and NASA senior management have not diminished. In fact, because of the environment imposed on the Shuttle Processing Directorate, the requirements have increased. The Shuttle Processing Directorate must begin to analyze how its workforce will evolve in the privatization and commercialization environments and prepare a plan for this evolution. Just as important is the need for the HEDS Enterprise management to provide clear guidance on additional tasks to transition to SFOC, and when the Shuttle program will move to the privatization and commercialization environments.

The team found some evidence that attrition prompted some of the transition activity, and there is a concern that further attrition and reassignment may drive premature task transition in the future. Given today's flight rate, the Shuttle Processing Directorate has the minimum workforce necessary to conduct daily business; however, critical mass has

not been defined for the present set of responsibilities and tasking. The Shuttle Processing Directorate believes that more personnel are needed, but the Directorate has not developed a plan to meet its responsibilities in the event that there is no augmentation of workforce. This plan is needed. KSC should corporately determine what the minimum Shuttle Processing Directorate cadre would be to discharge the NASA-retained responsibilities.

The team observed that the Shuttle Processing Directorate workforce is not getting sufficient opportunities to strengthen their individual technical skills in preparation for KSC's future. There is little evidence of structured training plans for all positions, and expectations for each position are not fully documented. The resources to support the needed training plans, such as simulation capability, are inadequate to support workforce development and proficiency. Where they do not exist, detailed training plans for each position must be prepared.

The current practice of not allowing Shuttle Processing Directorate engineers to transfer to other organizations at KSC is adversely affecting morale. This practice, coupled with the fact that many engineers are frustrated that the job has changed significantly from what they were recruited and hired to perform, could lead to loss of some of the workforce from the Agency. Each individual has the desire to grow and have opportunities. Although personal goals may not be aligned with the Shuttle Processing Directorate mission, the workforce should be offered every opportunity to achieve their individual goals.

The establishment of an R&D capability at KSC will evolve over the next five-to-ten years, yet the Shuttle Processing Directorate workforce believes that KSC management wants to cease operational work and concentrate on R&D immediately. This simply is not true. The Spaceport Technology Center concept complements rather than replaces existing operations, especially operations performed by the Shuttle Processing Directorate. Shuttle Processing Directorate management needs to assure that the workforce understands that the migration to an R&D Center is an evolutionary process that is just now beginning. It is important for the workforce to understand that NASA will never be completely removed from operations.

At this time, the Shuttle Processing Directorate is capable of meeting all requirements with the current workforce; however, there are cases where experienced staff are required to leave development activities and return to the Shuttle Processing Directorate to support launch activities. If the flight rate increases, the capability of meeting all the requirements may become a challenge if existing resource shortfalls and demands continue. Note that the capability of the Shuttle Processing Directorate to fulfill its assigned requirements today is based on the ability of the workforce and their individual dedication to making it work.

The processes used by the Shuttle Processing Directorate are deemed stable. This determination is subjective because there are no metrics collected on the NASA-owned processes. It is difficult to determine if the Shuttle Processing Directorate processes are

under control. This is primarily due to the fact that there are no metrics on NASA-owned processes. The Process Insight and Trend Analysis (PITA) system is used to collect NASA-generated metrics on the SFOC processes. Although it appears to be uniformly conducted, there are no feedback loops to determine if the PITA process is indeed effective. More needs to be done in this regard.

Our team did not have the opportunity to pursue in detail redundancies among organizations. However, throughout the assessment, our team looked for areas of obvious overlap or redundancy with other directorates or organizations. Beyond the inherent redundancy among the Shuttle Processing Directorate and SFOC/Ground Operations organizations the team did not find a great deal of redundancy. There appears to be some efforts that could be consolidated across the Center, especially in the facilities design and project management areas and the facilities maintenance arena.

The team members acknowledge the outstanding support they received throughout the independent assessment process. The team's point of contact in the Shuttle Processing Directorate, Steve Robling, efficiently coordinated on-site activities and enabled access to required data. Ruth Harrison, Shuttle Project Engineering Office Chief, assisted greatly by acquiring all data requested by the team. Special thanks go to Laura Osorio for her untiring efforts in scheduling team interviews with Shuttle Processing Directorate engineers. Finally, the entire review team thanks the Shuttle Processing Directorate workforce and management for their participation and for the frank, open conversations that were essential to this review.

INTRODUCTION

The Director of the Kennedy Space Center (KSC) Shuttle Processing Directorate requested the Human Exploration and Development of Space (HEDS) Independent Assessment (IA) organization conduct an assessment of the Shuttle Processing Directorate operations.

SCOPE

The independent assessment of the Shuttle Processing Directorate focused on:

1. Space Shuttle program requirements.

2. The mission statement and Business Objectives and Agreements (BOA).

3. Management documentation and procedures for day-to-day operation (daily management of the Shuttle Processing Directorate staff).

4. Surveillance plans, processes, and metrics.

5. Certification of Flight Readiness process.

6. Launch and landing preparation and execution.

7. Development activities, such as the Checkout and Launch Control System (CLCS), launch site equipment, and construction of facilities projects.

OBJECTIVES

The basic objectives of this independent assessment were to:

1. Determine the capability of the Shuttle Processing Directorate to meet assigned requirements and responsibilities with the available human resources, in terms of critical skills, training, etc.

2. Assess the stability of the processes used by the Shuttle Processing Directorate.

3. Determine if the Shuttle Processing Directorate processes are under control.

4. Identify areas of overlap or redundancy with other Directorates.

APPROACH

The independent assessment of the Shuttle Processing Directorate was a review of NASA civil service management, workforce, and processes. The team was interviewed and assigned by the Director, HEDS IA, and approved by the Associate Administrator for Safety and Mission Assurance. The assessment team included personnel with extensive skills and experience in operations management, vehicle processing, mission execution, and process verification. The team members are listed below.

- William Hill, HQ/QE: Team Executive: Office of Safety and Mission Assurance, Space Shuttle Operations Safety and Mission Assurance.

- Rich Jackson, JSC/DA8: Missions Operations Directorate, Flight Director.

- Randy Register, 45 Space Wing, Chief, Quality Assurance.

- Jerry Ross, JSC/CB: Astronaut and Astronaut Office Branch Chief KSC Operations Support.

- Mike Spence, The Aerospace Corporation: Principal Director; Processing, Integration and Test of Launch Vehicles for the Air Force at Cape Canaveral Air Station.

- Diane Stoll, 45 Space Wing, Chief, Quality Assurance, MLV/Payloads/LO&SC.

- Brian Kelly, HEDS Independent Assessment Director (acting), ex-officio member.

The team conducted the assessment using the four-part process outlined below.

1. Data gathering to collect and review documentation on requirements, responsibilities, processes, procedures, metrics, resource management, and other pertinent areas.

2. On-site interviews and briefings to validate and measure processes, procedures, and metrics against the documentation.

3. Evaluation of information obtained through the first two parts.

4. Formulation of observations, recommendations, and alternative solutions for meeting the recommendations.

The team used this four-part process to achieve the objectives of the independent assessment. Specifics on how the team approached each objective are detailed below.

To begin gathering data, the team solicited initial input from the Shuttle Processing Directorate by inserting six questions into a survey that is administered annually to the

Shuttle Processing Directorate. The team used the results of the survey to identify areas for further penetration, such as critical skills, personnel training issues, and task prioritization issues. The team sought additional information about these areas during the interview process.

To determine the capability of the Shuttle Processing Directorate to meet its responsibilities with the available resources, the team reviewed the resource management activities. Specifically, the team reviewed the current skills available to the Shuttle Processing Directorate, the management of critical skills, and efforts to improve or change the manner in which business is conducted. The team also assessed the Space Shuttle program requirements to understand the impact of the assigned requirements on the Shuttle Processing Directorate resources. Additionally, the team assessed the SFOC surveillance activities to determine the ability of the Shuttle Processing Directorate to evaluate and monitor the capability, stability, and controllability of SFOC/Ground Operations processes for preparing the Space Shuttle vehicle for launch.

To assess the stability of the processes owned by the Shuttle Processing Directorate, the team planned to review how process effectiveness is measured and to evaluate the metrics used to determine how well the Shuttle Processing Directorate is meeting its assigned roles and responsibilities. The team interviewed well over 60 Shuttle Processing Directorate engineers and managers (approximately 25% of the workforce).

To determine whether the processes were under control, the team assessed the influences and factors affecting the Shuttle Processing Directorate processes. The team reviewed the internal and external forces that affect change to the processes, and determined if the processes can remain stable and under control.

Throughout the assessment, the team looked for areas of overlap or redundancy with other directorates. While the team did not have an opportunity to pursue this area in great detail, there does appear to be some work that could be consolidated across the Center.

After considering the documentation reviewed and the large amount of data collected through direct interviews and briefings, the team formulated observations, recommendations, and potential solutions. This report provides the team's objective independent assessment to help the Shuttle Processing Directorate pinpoint issues and steer improvement efforts.

During the assessment process, the team identified areas where a formal observation or recommendation was either not warranted or deemed out of scope. These informal observations and proposed solutions are included in Appendix B.

OBSERVATIONS AND RECOMMENDATIONS

General Observations:

The team found that the Shuttle Processing Directorate workforce was highly dedicated and professional. They believe it is a privilege to work on the Space Shuttle. A large majority of the staff members indicated that they believe the appropriate level of work was transitioned to the SFOC, USA Ground Operations. However, many Shuttle Processing Directorate staff members are concerned about future operations.

Post-transition Shuttle processing has been accomplished in an environment that is artificial relative to required flight rate. The team reviewed the requirements levied on the Shuttle Processing Directorate, through NSTS 07700, its subordinate requirements, and the SFOC transition plan. At this time, the Shuttle Processing Directorate is capable of meeting all requirements with the current workforce; however, there are cases where experienced staff are required to leave development activities and return to the Shuttle Processing Directorate to support launch activities. If the flight rate increases, the capability of meeting all the requirements may become a challenge if existing resource shortfalls and demands continue. There are several factors that could affect the overall Space Shuttle processing capabilities. These factors include:

- a higher flight rate, 7-to-9 flights per year versus the 3-to-4 experienced for the most part since transition

- the full effect of the Checkout and Launch Control System (CLCS), with the development and test of application software by the engineering workforce and the validation of associated changes to Operations and Maintenance Instructions (OMI's)

- the increased demands on the workforce to meet Spaceport Technology Center goals.

The uncertainty that accompanies the future is a real threat to their ability to perform at the level of excellence demonstrated in recent history. The capability of the Shuttle Processing Directorate to fulfill its assigned requirements today is based on the ability of the workforce and their individual dedication to making it work.

The processes used by the Shuttle Processing Directorate are deemed stable. This determination is subjective because there are no metrics collected on the NASA-owned processes. It is difficult to determine if the Shuttle Processing Directorate processes are under control. This is primarily due to the fact that there are no metrics on NASA-owned processes. The Process Insight and Trend Analysis (PITA) process is used to collect NASA-generated metrics on the SFOC processes. Although it appears to be uniformly conducted, there are no feedback loops to determine if the PITA process is indeed effective. More needs to be done in this regard.

Our team did not have the opportunity to pursue in detail redundancies among organizations. However, throughout the assessment, our team looked for areas of obvious overlap or redundancy with other directorates or organizations. Beyond the inherent redundancy among the Shuttle Processing Directorate and SFOC/Ground Operations organizations the team did not find a great deal of redundancy. There appears to be some efforts that could be consolidated across the Center, especially in the facilities design and project management areas and the facilities maintenance arena.

The team's most significant observations are listed below:

* Safety remains the top priority among the workforce. There is some uncertainty among the Shuttle Processing Directorate workforce when determining the second priority. This further prioritization is often left to the individual to determine.

* Communication processes, both external and internal to Shuttle Processing Directorate, are not as effective as needed.

* The continued uncertainty of the milestones for the Space Shuttle program concerning further task transition to SFOC, privatization, and commercialization makes strategic planning, workforce deployment, and prioritization of requirements difficult.

* The Shuttle Processing Directorate is doing more with less resources than any time in its history and performing a more diverse spectrum of work. There needs to be further definition of workforce critical mass for present responsibilities and tasking.

* There is no plan to compensate for the loss of staff in the Shuttle Processing Directorate if there is no further augmentation of the workforce.

* There is little evidence of structured training plans for all positions, and expectations for each position are not fully documented. Additionally, the resources to support the needed training plans, such as simulation capability, are inadequate to support workforce development and proficiency.

* The establishment of an R&D capability at KSC will evolve over the next five-to-ten years, yet the Shuttle Processing Directorate workforce believes that KSC management wants to cease operations work and concentrate on R&D immediately. This simply is not true. The Spaceport Technology Center concept compliments rather than replaces existing operations, especially operations performed by the Shuttle Processing Directorate.

Each of these significant observations, identified with a "*" in the text, will be discussed in detail along with other important observations. Specific recommendations are provided with each observation. Significant recommendations are summarized at the end of this section.

Observation #1: Everyone interviewed indicated that safety is the top priority and that safety will not be compromised. The schedule will slip to maintain safety.

To the Shuttle Processing Directorate management and workforce, the future poses difficult challenges. The expectations of Space Shuttle program management, KSC management, and NASA senior management have not diminished. In fact, because of the environment imposed on the Shuttle Processing Directorate, the requirements have increased during a period of declining resources. While everyone interviewed indicated that safety will not be compromised, those interviewed also indicated that the schedule could suffer and costs would most likely increase.

Recommendation #1: Shuttle Processing Directorate management must continue to assure that safety is the top priority. This tenet must be reinforced with the workforce as often as possible.

Observation #2: After safety, there is some uncertainty among the Shuttle Processing Directorate workforce when determining the second priority. In some cases, the prioritization is left to the individual to decide.

Everyone who was interviewed agreed that the top priority is to safely process the Shuttle and that the Shuttle program management will not sacrifice safety for schedule, cost, or any other reason. Beyond safely processing the Shuttle, the Shuttle Processing Directorate workforce indicated some uncertainty as to their next priority. In simplest terms, the workforce does not know whether the second priority is completing surveillance tasks or conducting development activities. Surveillance activities are important because they support the Certification of Flight Readiness process and safety. Further confounding the uncertainty is the fact that many believe that the decisions concerning priority of tasks are left to the individual worker, with no intervention or guidance by management. For example, instead of working with Shuttle Processing Directorate managers, development activity managers are directing the Shuttle Processing Directorate engineers to tell their managers that they need to spend more time on the development activity. This is especially true in the case where Shuttle Processing Directorate engineers are working part time on the CLCS development. Another conflict in priorities is perceived between Shuttle processing and new projects/development. Although Spaceport Technology Center development is needed to sustain KSC over the long-term, there should be a balance between surveillance activities and development.

Recommendation #2: The Shuttle Processing Directorate must maintain safety as the top priority (which includes surveillance tasks), document the priority of other tasks, and assure clear communications of priority to the Shuttle Processing Directorate workforce.

Observation #3: External communications, those with the KSC senior management and Shuttle program management, appear ineffective.

When comparing the results of interviews with Shuttle Processing Directorate management, KSC Senior management, and Shuttle program management, the team noted that there is discontinuity in the communications paths. For example, the team was intrigued to find that, outside the Shuttle Processing Directorate, management seems unaware of the issues facing the Shuttle Processing Directorate in supporting launch. Discussions concerning staffing, especially for launch, found that management outside of the Shuttle Processing Directorate believes that there are too many NASA people in the firing room. Although there was no root cause uncovered, the team is concerned that the messages going to Center and Program management are not effectively being received. It is not clear why this is happening, but it seems that the complete message is not getting through.

Recommendation #3: As part of the ongoing management process, the Shuttle Processing Directorate should continue face-to-face communications with Center and Shuttle program management to formalize the requirements for NASA-retained functions performed by the Shuttle Processing Directorate in the near- and long-term. Organizational expectations should be clearly documented and approved by all parties concerned.

＊Observation #4: Communications within the organization are not as effective as needed.

The continued open flow of information throughout the Shuttle Processing Directorate is important to its efficiency and effectiveness. The team received varying opinions on the success of vertical communications. Most stated that communications up and down were effective. Some were concerned that there had been only one all-hands meeting (to present the impending reorganization) over the past year. It was also noted that an open-door policy replaces regularly scheduled senior staff meetings. Frequency of staff meetings at the division level varied among the divisions, from daily to non-existent. Some indicated that there appears to be no means by which employees can make suggestions or provide input to upper management without filtering by intermediate management levels. Additionally, e-mail is often substituted for direct conversation to convey information. E-mail may not always be the most effective way to present information.

Recommendation #4: The Shuttle Processing Directorate should review communications methods used in the Shuttle Processing Directorate and use direct, face-to-face interaction as much as possible for communications within the Shuttle Processing Directorate.

Observation #5: Attrition tended to drive the transition strategy and there is a concern that attrition and reassignment may impact the ability of the Shuttle Processing Directorate to successfully perform its function.

For the Shuttle Processing Directorate, the transition of ground operations tasks to SFOC is over. The workforce for Shuttle processing has been reduced by one-half to two-thirds since 1994. Of the tasks retained by NASA, all are documented to be highly complex tasks or governmental functions dictated by legislation or regulations. Any consideration of transition of the remaining NASA tasks will require an in-depth risk assessment to identify what, if any, additional risk is present after task transition.

Many who were interviewed indicated a concern that attrition was driving the transition strategy. They believed that several tasks were prematurely transitioned because the person doing the task was no longer available, due to attrition or reassignment. In some cases, the transition became more of a reactive occurrence than a carefully executed plan. The assessment team's concern is that further attrition and reassignment may prompt premature task transition. Shuttle Processing Directorate management must confront workforce issues and predict, rather than react to, the effects of attrition. The requisite planning and risk assessment activities need to begin immediately to permit a predictive, risk-based decision process for managing workforce attrition.

Recommendation #5: As soon as practical, the Shuttle Processing Directorate should begin planning and risk assessment activities to assure a predictive, risk-based decision process for managing workforce attrition.

＊Observation #6: The continued uncertainty of the milestones for the Space Shuttle program makes strategic planning, workforce deployment, and prioritization of requirements difficult. There is an apparent disconnect among the Program Commitment Agreement (PCA) and the direction of the Space Shuttle program regarding further task transition to SFOC, privatization, and commercialization.

There is continued uncertainty concerning the direction of the Space Shuttle Program. The PCA identifies a declining civil service workforce in the Shuttle program in the near term, while there appears to be no planning in work to transition additional tasks to SFOC. There is no set schedule for the privatization and commercialization of the Space Shuttle. Because the milestones for additional task transition, privatization, and commercialization are uncertain, there is no foundation from which KSC, and the Shuttle Processing Directorate in particular, can accomplish strategic planning, workforce deployment, and prioritization of requirements. Consideration should be given to the future roles and responsibilities of the Shuttle Processing Directorate after Space Shuttle activity is privatized and commercialized. Planning should begin to achieve this future state. KSC must look beyond Shuttle operations and International Space Station (ISS) assembly to determine the capabilities and experience that will be needed at the Center in the future. The Shuttle Processing Directorate management and workforce will be part of that future, but their role is not presently defined. Operations expertise at some level, similar to that held by the Shuttle Processing Directorate workforce, is needed to continue development efforts and process new

launch vehicles. There is also an immediate need to assess and determine the degree of additional risk that NASA is willing to take. Until there is a common understanding of level of risk and margin, further task transition is unwarranted.

Recommendation #6a: The Shuttle Processing Directorate should begin the analysis of how its workforce will evolve in the privatization and commercialization environments, prepare a plan for this evolution, and communicate the results of the planning process to the HEDS Enterprise.

Recommendation #6b: The HEDS Enterprise management needs to provide clear guidance on additional task transition to SFOC, and when the Shuttle program will move to the privatization and commercialization environments. The Shuttle PCA should be modified to reflect the plan.

Observation #7: The Shuttle Processing Directorate workforce is not getting sufficient opportunities to strengthen their individual technical skills to support NASA's future.

The Shuttle Processing Directorate's mission statement, "to maintain world-class expertise in Shuttle (Reusable Launch Vehicles) processing and apply that expertise to upgrades, new technology, new development, and future vehicles," describes a challenge the organization faces. This challenge involves balancing the need to maintain expertise in Shuttle/RLV processing while reducing day-to-day management of the processing effort. There needs to be a means for the Shuttle Processing Directorate workforce to maintain near-daily contact with the test and on-floor operations on vehicles in the Orbiter processing facilities, the vertical assembly building, the hypergolic maintenance facility, and the pads. Whether through increased surveillance activities, either sampling or in-depth observations, or through other means, the NASA workforce should be offered the opportunity to stay close to the hardware, software, and procedures during vehicle processing. These activities will foster the ability for the workforce to maintain their collective vehicle processing expertise and proficiency.

Some of those interviewed believed that the Shuttle Processing Directorate workforce should be engaged in challenging SFOC to improve ground operations processes. Pursuing this course of action could motivate the Shuttle Processing Directorate workforce while providing improvements that will be valuable to the Agency. NASA must hold SFOC accountable for performing their assigned tasks and for process improvement; however, there is little effort at this time to do so. A starting point might be to perform a throughput study to determine the problem areas in Shuttle processing and to focus improvement efforts on those areas that impede increased flight rates.

Shuttle Processing Directorate management must make certain that the workforce has the opportunity to refresh their technical skills and talents and to remain marketable. This is a fundamental responsibility of every management team and one that will, if accomplished, assure the growth and success of the overall organization. A comment

was made that there is no comprehensive or standard training on future vehicles and the associated technologies. While it is difficult to carry out this objective when resources are so scarce, it is one of the most important objectives found in the Shuttle Processing Directorate Business Objectives and Agreements (BOA). (It is interesting to note that none of the responsibility descriptions found in the BOA address this important objective.)

Recommendation #7: Shuttle Processing Directorate management must make certain that the workforce has the opportunity to hone and refresh their technical skills and talents and to remain marketable. The Shuttle Processing Directorate workforce must have multiple opportunities to stay close to the hardware, software, and procedures during vehicle processing.

✳Observation #8: The Shuttle Processing Directorate is doing more with less resources than any time in its history and is also performing a more diverse spectrum of work. The Shuttle Processing Directorate workforce critical mass has not been defined for the present responsibilities and tasking.

There are currently many demands on the Shuttle Processing Directorate workforce. These include: NASA-retained tasks; on-going surveillance activities of the SFOC; review and approval of out-of-family disposition; Checkout and Launch Control System (CLCS) development and test; Shuttle upgrades assessments; Spaceport Technology Center efforts; Agency-level requirements (ISO 9000, Voluntary Protection Program, etc.); and personnel development/training. The Shuttle Processing Directorate has established Space Shuttle processing as the first priority. If the flight rate increases, the development tasks will be delayed. However, development efforts are key to the future of KSC. There is clear evidence that development efforts, such as CLCS, suffer when the Shuttle Processing Directorate workforce focuses on a launch.

Since the early 1990's, the Shuttle Processing Directorate workforce has continually declined, decreasing by one-half to two-thirds since 1994. Although a significant amount of work was transferred to the SFOC, the reduction in resources (through buy-outs and assignment to development efforts), combined with the introduction of surveillance tasks, left the Shuttle Processing Directorate workforce with little to no margin or surge capability. Since there is little to no margin with an annual flight rate of four flights over the past two years, there is a concern for the ability of the Shuttle Processing Directorate workforce to accommodate a flight rate of eight or more flights per year.

There is a need to assess the staff-hours consumed for both flight-rate dependent and independent tasks, including projected development, administrative, and training tasks, to determine the required Shuttle Processing Directorate workforce. In doing so, the Shuttle Processing Directorate should include responsibilities of secretaries and administrative positions. By not including these positions, the Shuttle Processing Directorate implies that these positions are unimportant to the organization. Also, the

contribution made by the workers in these positions does not get counted. (The entire philosophy for eliminating administrative support, such as secretaries, has led to already over worked engineers performing administrative duties.)

The Shuttle Processing Directorate has witnessed a significant loss of experience and corporate knowledge in recent years. Understandings and agreements made between Shuttle Processing Directorate management and SFOC Ground Operations management have been lost. There are few systems experts in the engineering ranks. The majority of the engineering workforce joined the NASA ranks after Challenger. The inability to hire over the past five years has prevented infusion of new talent, new ideas, and new technology knowledge. KSC management must assess the engineering expertise in the combined NASA/SFOC workforce to determine the relative strengths and weaknesses. Once this information is gathered, an assessment of allocation of resources and critical skills can be performed to determine if there are opportunities for NASA to further reallocate resources. Just as critical is the need to determine what level of expertise is required in the NASA engineering ranks, i.e., expert-level knowledge, systems-level knowledge, or functional-level experience. The Shuttle Processing Directorate should clearly define the job of the NASA engineer and the role of NASA civil servants in Shuttle processing.

The team observed that the Shuttle Processing Directorate, and KSC as a whole, should consider bringing on a mix of graduate and undergraduate students as co-ops instead of solely undergraduates. Graduate-student co-ops would provide NASA with new methods and technologies for application in Shuttle upgrades and new development efforts. Many people interviewed offered this solution for inserting new thought processes into the existing system.

Recommendation #8: KSC should corporately determine what the minimum Shuttle Processing Directorate cadre would be to discharge the NASA-retained responsibilities.

Observation #9: The demand on the Shuttle Processing Directorate workforce by the Checkout and Launch Control System (CLCS) development effort has yet to peak. CLCS will continue to impact on Shuttle Processing Directorate resources.

The team is concerned that CLCS has not yet reached the point of peak demand on the Shuttle Processing Directorate workforce. To date, most of the effort has focused on the development and testing of the common elements of the system. The key to making CLCS useful is the application software, which needs to be developed and tested by the Shuttle Processing Directorate engineering workforce. In addition, nearly all of the Operations and Maintenance Instructions (OMI's) will require revision to reflect the CLCS displays and procedures. It is not clear how CLCS will be managed since the current environment does not allow a large number of engineers to be dedicated to CLCS. The scope of the project has been reduced, especially in the facilities area (Kennedy Complex Control Center). The removal of certain facility functions from CLCS is impacting other areas. CLCS will be considered out-of-family, requiring direct

oversight for two-to-five years. The team is concerned that there will not be sufficient NASA staff in place to accept ownership of CLCS when it is completed in a few years. CLCS will continue to impact Shuttle Processing Directorate resources.

Under the current resource allocation approach, development activities will be preempted by Shuttle processing efforts, especially on launch day. As witnessed during the STS-93 launch attempts, CLCS and other development efforts that are important to KSC and KSC's future were neglected.

Recommendation #9: The Space Shuttle program should review the CLCS application software development and test efforts to determine the projected resource impact. Furthermore, the Space Shuttle program should utilize the recent independent assessment of the CLCS program and, if necessary, re-baseline scope of the CLCS project.

✳Observation #10: There is no plan to compensate for the loss of staff in the Shuttle Processing Directorate if there is no further augmentation of the workforce. Core competency gaps in Shuttle Processing Directorate, taking into account retirement projections, estimated attrition, and the time needed to acquire and train replacements, have not been identified.

Acquiring and maintaining critical skills and the proper skill mix are a challenge, especially in an environment where little to no hiring is authorized. Through repeated demonstrations of need, KSC has recently received approval for a "one-for-two" hiring authority, meaning that one person can be hired for every two that leave. KSC has, for the most part, accomplished this level of hiring Center-wide in the last year. The Shuttle Processing Directorate has been allowed to hire two engineers in the last year; both have been assigned to the Fluids Division. KSC has also been given a four-year reprieve in achieving the Civil Service, Full-Time Equivalent (FTE) target. These are temporary measures that will not fix the problem in the long term.

For example, one of the staffing challenges in the Shuttle Processing Directorate is in the area of the Quality Assurance Specialists (QAS's). QAS's are required to perform Government Mandatory Inspection Points (GMIP's). Several years ago, HEDS Enterprise management determined that the Agency's and KSC's future did not require a technician workforce, such as QAS's. This decision led to the departure of many QAS's. In planning for the future, the Safety and Mission Assurance (SMA) management made the assumption that there would no longer be a requirement for GMIP's. After evaluating all GMIP's against a set of criteria to determine if a GMIP could be eliminated, the Space Shuttle program found that approximately 8,500 GMIP's would remain in place for an indefinite period of time. When comparing the number of GMIP's required with the number of QAS's remaining, the Space Shuttle program determined that there were 17 fewer QAS's on-board than were needed just to complete the GMIP's (given three Orbiters in flow being readied to be launched approximately six weeks apart). Note that this did not include the number of QAS's that

would be required to perform surveillance tasks. The Space Shuttle program is looking into many different options to augment this shortfall. If the flight rate increases as expected, the surveillance tasks would continue to be neglected.

NASA engineers continue to be required to staff each console for the S00007 terminal launch countdown; T-6 hours to launch. NASA performs key leadership roles during the launch countdown, a NASA-managed function. The key leadership positions are the Launch Director (with the Assistant Launch Director), the NASA Test Director, and the Shuttle Process Engineer, located at the Integration Console. These are the only positions where NASA managers or engineers are prime at the console; all other systems consoles have SFOC engineers as the prime. The prime position directs and coordinates the activities at the console and is responsible for disposition of all problems identified during the countdown. The final go/no-go for each systems console is given by the console prime. All SFOC console operators/engineers are stand-board tested to demonstrate that they possess the knowledge and skill to operate direct console operations. The team found when trying to determine the adequacy of the stand-board process, different opinions emerged. Some stated that, because it is a one-time occurrence with no periodic re-qualification, the stand-board process is not adequate. The NASA engineers at each console are not stand-board tested. NASA supervisors are tasked to certify that the NASA engineers are qualified for systems console operations during integrated simulations and launch.

Since Shuttle Processing Directorate engineers are not on console during nominal flow process testing of the vehicle, the value the Shuttle Processing Directorate engineer provides on launch day is questioned, particularly if the engineer has been working CLCS or other development activities and joins the process on the day of launch. The team believes that the Shuttle Processing Directorate engineers have the critical skills and the ability to analyze operations and anomalies based on their experience. Shuttle Processing Directorate engineers on console understand the application software concept and how the software was designed and implemented. In some cases, the Shuttle Processing Directorate engineer is the most experienced person on console and can provide knowledge that is otherwise not documented. As long as the Shuttle Processing Directorate engineers can maintain proficiency, they should remain on console for launch.

Recommendation #10: The Shuttle Processing Directorate must develop a plan to formalize, prioritize, and plan for the staffing needed to meet its requirements in the future, including critical skills and support functions. The plan should address a worst-case scenario for critical skills to assess the degree of response needed.

Observation #11: Succession planning for key positions is non-existent and has led to an organization with many vacancies or acting managers in key positions.

In addition to the loss of critical skills and expertise over the last few years, there has recently been a loss of key engineering and management staff. This has resulted in

many vacancies in management positions. The extended period of time that key positions have gone unfilled has adversely affected the workforce. The team is extremely concerned with the current state of the Launch Director position. This position is too critical to not have qualified, trained people ready to move into a vacated position. The path to become a Launch Director has always been undefined. There needs to be a succession plan in place to define the critical skills, knowledge, and experience needed to become a Launch Director, if the position is to be maintained. Succession planning and skills definition are also required for the Shuttle Processing Engineer (SPE) and NASA Test Director (NTD) positions. There is currently no real training plan in place to become an SPE (the Launch Director, Engineering Director, and previous SPE's evaluate the performance of SPE candidates during simulation to make a selection for that position). Key management positions have also gone unfilled for nearly a year. The proposed Shuttle Processing Directorate reorganization had been in a state of uncertainty until recently. The team is hopeful that the new organization will be in place and all positions filled before the end of November 1999.

Recommendation #11: The Shuttle Processing Directorate should formalize succession planning for key positions that are to be maintained as NASA-retained functions.

＊Observation #12: There is little evidence of structured training plans for all positions; expectations of the positions are not fully documented.

The team found very little evidence of structured training plans for engineering and management positions beyond basic training for all engineers. There are no formally documented position expectations, which are necessary to formulate a structured training plan. For the most part, the existing engineering workforce trained through on-job-training (OJT) and with daily contact with mentors who were the systems experts. In the last 5 years, many of the system experts have retired and, since the transition, the ability to access the processing areas has been diminished due to time taken to perform surveillance and other duties. For these reasons, formal training plans should be prepared for all positions to establish a common understanding of the knowledge required to do the job. This is useful, especially in an environment where it is desirable to cross-train engineers on multiple systems. It is also useful in an environment where engineers are matrixed to other organizations for long periods of time and then return to the Shuttle Processing Directorate.

Along with the training plans, the Shuttle Processing Directorate must assure that the resources to implement the plans are available. Resources to support training include time to accomplish training, workbooks, classrooms, study materials, and the curriculum development. Management must commit to implementation or the effort will be wasted.

In addition, there is a potential for hiring additional engineers. Training plans must address training college graduates with little or no experience. Depending on the position and the abilities of the new-hire, it takes approximately two years to adequately

train an engineer to be able to approve the resolution of out-of-family issues. In today's environment, this may take longer because NASA no longer has ready access to review in-family documentation and the associated hardware. Also, there are few mentors available and much less time for mentoring. The Shuttle Processing Directorate should consider reinstating retired experts for temporary periods of time to provide additional mentoring capability to the younger workforce and to help train new-hires. A concept for developing a comprehensive training plan is provided in Appendix A.

Recommendation #12: The Shuttle Processing Directorate should formally document the expectations and prepare and implement detailed training plans for each position in the Shuttle Processing Directorate workforce. This is especially important now that there is a potential for hiring additional staff.

✳Observation #13: The available simulation capability is inadequate to support workforce development and proficiency.

As training plans are essential, so to is the ability to implement the training plans by providing both simulation and computer-based training.

Currently, NASA engineers are only required to staff the consoles during the S00044 Integrated Simulation, S00017 TCDT, and the S00007 Launch Countdown, as well as those called out in the IDOs. These are also the only events where the entire launch team is brought together to perform as a single unit. The NASA engineers' knowledge on launch day is supported only by the amount of time that they are on console during the early parts of S00007. Many of the engineers who were interviewed said it takes at least two days on console to gain the self-confidence after being away for extended periods of time.

Until recently, the only way to conduct simulations was to do so in one of the firing rooms. This requires the firing room to be off-line and, with three or four Orbiters in flow, this is rarely possible. In addition, when a simulation is run in the firing room, the full up, integrated test team is required. This is a significant resource expenditure. Although there will always be a need for integrated test team simulations to assure team cohesion and proficiency, there is a need for subsystem and systems level simulation capability to support a comprehensive training program. Off-line capabilities for systems-level simulations are being developed and more attention and resources are needed to get this simulation capability in place. The subsystem, or box level simulation capability is required to round out the total training package. This is not just a Shuttle Processing Directorate problem; SFOC would also benefit from similar capabilities. The total, three-tier approach to training (integrated system, subsystem and associated interfaces, and subsystem-level) is essential to support the training plans that are to be developed. The Shuttle Processing Directorate can and should partner with SFOC on this effort, because the NASA and SFOC workforces will ultimately share it. Computer-based training of any type would be extremely useful given the varying schedules of the workforce and the general lack of training funds available for off-site training.

Recommendation #13: The Shuttle Processing Directorate should apply the needed resources to increase the development of the three-tier simulation capability to support the needed training program.

Observation #14: The current practice of not allowing Shuttle Processing Directorate engineers to transfer to other organizations at KSC is adversely affecting morale. This is coupled with the fact that many engineers are frustrated that the job has changed significantly from what they anticipated. This could lead to loss of some of the workforce from the Agency.

The Shuttle Processing Directorate management has a significant challenge in motivating its workforce. Surveillance is not what the engineering workforce had trained to perform. Engineers are frustrated that the job has changed significantly from their expectations. The majority of the Shuttle Processing Directorate engineering workforce entered NASA approximately 12 years ago. These engineers are now in a position to make a career change that would allow them to move to another area in NASA or private industry and have another 20 years of work. The large number of Shuttle Processing Directorate engineers who transferred to the Multi-Element Integration Test (MEIT) and new development work when provided the opportunity demonstrated this clearly. In the past, civil servants were somewhat trapped in Government jobs because their retirement assets were only available in the Government. Going to private industry meant starting over with a new retirement plan. This is no longer the case due, in part, to the transportability of retirement assets provided by the Civil Service Retirement System (CSRS) and Federal Employee Retirement System (FERS). The team's concern is that KSC and the Shuttle Processing Directorate are in a position to lose a significant portion of their experience base to private industry if there is no way to motivate the work force to perform surveillance.

The team was repeatedly told that many of the engineers that left the Shuttle Processing Directorate to perform MEIT were expected to have returned to the Shuttle Processing Directorate. MEIT has taken longer, has been more work, and has consumed more resources than originally planned. MEIT has proven to be valuable to the ISS program and will help assure mission success. Notwithstanding the value, the plan was to have some of the workforce back in the Shuttle Processing Directorate and retrained before the flight rate increased to a sustained rate of eight flights per year. This plan has yet to be realized. The pending Center-wide reorganization, with the potential for a central engineering organization that matrixes engineers to projects, may also not be the answer. There are concerns with this approach, including the absence of a standard process for reporting and supervision of staff, and the potential for competing priorities between the programs and central engineering organization. Priorities need to be clearly documented and agreed upon among all concerned organizational elements. Recent experience in the Shuttle Processing Directorate indicates that matrixed personnel are often overlooked when it comes to awards,

promotions, and new-development opportunities, and have a feeling of being disconnected.

Morale in most areas in the Shuttle Processing Directorate is now on the rise. Many on the NASA side compare their morale to that of their contractor counterparts and believe morale is better on the NASA side. However, the team found that the current practice of not allowing engineers to transfer to other organizations at KSC does adversely affect morale. The Shuttle Processing Directorate is not alone at KSC in having insufficient staff to perform their assigned tasks. However, not allowing the workforce to pursue their career goals will worsen morale and may ultimately lead to the loss of workers. This is a management problem and is not one that should be borne by the workforce.

Recommendation #14: The Shuttle Processing management should recognize that the practice of not allowing engineers to make career-enhancing moves is counterproductive. KSC should review their procedures for back-filling positions vacated based on Center priorities.

Observation #15: There are no personnel development metrics that address the relative wellness of the Shuttle Processing Directorate workforce.

There are no personnel development metrics that address the relative wellness of the Shuttle Processing Directorate workforce. This leads to the inability to understand workforce development issues. For example, the Shuttle Processing Directorate should be able to determine how many hours of training the employees are offered and how many workers have gone back to school to get advanced degrees. The team suggests the following to help fill this void:

- Percent of training completed versus planned, with 100% as the goal.

- Percent of training travel budget spent, with 100% as the goal.

- Number of annual leave hours lost or donated to prevent loss because the time was not available for use, with a goal of zero.

- Number of credit hours lost because the time was not available for use, with a goal of zero.

- Percent of staff in advance academic courses, including bonus points for earned advanced degrees.

- Amount of time required for training to bring people up to speed, which could be used to justify lead time for hiring.

In addition to personnel development metrics, the Shuttle Processing Directorate might consider some form of training, similar to the Human Element Seminar at Wallops, to

provide managers with tools to rate workforce morale/stress and to be more sensitive to personnel needs. Additional training would also offer tools for the Shuttle Processing Directorate managers to assess the relative morale and stress level of their SFOC counterparts.

Recommendation #15: The Shuttle Processing Directorate should develop a set of metrics and management training, similar to those suggested, that address personnel needs.

Observation #16: There are no metrics on the effectiveness of Shuttle Processing Directorate processes, as the surveillance plan requires.

The team found several potential gaps in the Shuttle Processing Directorate surveillance process. There is a KSC requirement to have at least two metrics on NASA processes, yet there are no metrics on the effectiveness of the NASA-retained processes. Developing and tracking metrics on Shuttle Processing Directorate processes are stated requirements of the surveillance plan. Until metrics on NASA processes are in place, there are no means to demonstrate the effectiveness of the NASA workforce and, therefore, limited ways to justify the workforce content.

Recommendation #16: The Shuttle Processing Directorate should develop metrics on Shuttle Processing Directorate processes to provide a practical means to demonstrate effectiveness and performance.

Observation #17: There is a perception that the discipline in executing SFOC processes is degrading; however, the metrics are not supporting this perception. The surveillance plan does not require a formal, periodic review of the SFOC metrics.

The team discovered that the surveillance plan does not require the Shuttle Processing Directorate to conduct a formal, periodic review of the SFOC metrics. All metrics should be periodically reviewed for effectiveness and applicability. There is a perception that the quality of the contractor-prepared waivers and deviations is getting worse. There is also a perception that the contractor is not following written instructions completely, which results in missed steps/problems. Even if these perceptions are true, the problems may not be identified through the SFOC metrics. It is important to review what the metric is measuring and what it is indicating about the process being measured. Many of the SFOC metrics were defined in the original contract more than three years ago. Not all of the contract metrics are appropriate. Many metrics appear to be goal statements. Although many believe that the contract metrics can not be changed, the team discovered from the Contracting Officer's Technical Representative (COTR) that this was not true. All metrics including those in the contract can be changed.

The Shuttle Processing Directorate has done a commendable job of aggregating metrics in an effort to capture performance data on SFOC, make meaningful input to the award fee process, track key surveillance topics related to Shuttle processing, and characterize business activities at KSC. Although it appears intuitive that more data increases the probability of understanding a process, there may be a practical limit to the amount of material that can be meaningfully used. A determination of the relevance or value of information obtained would be useful. For this reason, the Shuttle Processing Directorate should begin a gradual process to evaluate every metric in use with a view towards determining its ability to produce information upon which action is taken. The review should focus on retaining or adding only those metrics that have an acceptable level of relevance to the Shuttle Processing Directorate mission. Metrics that do not provide information upon which action can be taken may not be worth retaining.

Recommendation #17: The Shuttle Processing Directorate should perform a formal, periodic review of the SFOC and NASA-generated metrics to assure that appropriate data is being collected, unnecessary data collection is deleted, and new data sets/sources are identified to assure process control.

Observation #18: The Process Insight and Trend Analysis (PITA) system is not effective. It is too complex, there is no analysis of data, and there is no feedback or periodic review.

The Shuttle Processing Directorate was challenged with becoming a world-class surveillance organization with world-class surveillance processes. There is a good surveillance plan in place and, generally, it is being followed. Surveillance tasks include approving resolution of out-of-family problems, assessing GMIP's, observing critical tasks or conducting in-depth observations (IDO's), reviewing SFOC-generated metrics, and sampling in-family operations and paper closure. The Shuttle Processing Directorate has developed the Process Insight and Trend Analysis (PITA) system as a repository for NASA-collected data on the SFOC performance. PITA sheets are used to record IDO's and sampling of in-family operations and paper closure.

The team received varying opinions concerning the effectiveness of the PITA system and the overall surveillance program. The PITA system is very labor intensive. Forms are manually filled out by the Shuttle Processing Directorate engineers and manually entered into the system. Efforts to automate the data collection and entry portion of the system are in work, but progress is slow. Many engineers are concerned about the lack of feedback once data is entered into the PITA system. Engineers are not asked to trend the data collected from flow to flow, so only perceptions of the level of SFOC performance accrue in the minds of the engineers. One concern raised is the fact that the PITA data is not normalized or weighted – one entry is the same as another, without regard for criticality of the task or process being measured. Evaluation of the data collected, the metrics of the SFOC performance, is not accomplished at the workforce level. It is also not clear to the workforce that all of the data required on a PITA sheet is

either useful or needed. The Shuttle Processing Directorate workforce needs to understand the rationale and use of each data field on the PITA sheet. The team found that PITA data is assembled and combined into packages that are used as justification for signing the Certification of Flight Readiness (CoFR) and for award-fee evaluation.

Recommendation #18: The Shuttle Processing Directorate should conduct a full review of the need and effectiveness of the PITA system and determine what data is important and what data is not important.

Observation #19: The core process metrics packages are not briefed to Shuttle Processing Directorate management in a collective forum where integration and sharing of information across the Directorate is accomplished.

On a quarterly basis, each of the core process managers assembles a package of surveillance data, based on NASA and SFOC-generated metrics, and forwards it to the Shuttle Processing Directorate management. The team was concerned to find that the metrics packages are not briefed to management in a collective forum. There is no integration or sharing of information gathered from the metrics packages. There is great value in integrating the information in a collective forum. If the core process managers are not offered the opportunity to look at other core process metrics, the full picture continues to be elusive and there is no ability to gain readily available intelligence from other areas that either confirms or refutes one's own information. This is a valuable aspect of the surveillance process that Shuttle Processing Directorate has seemingly been lost.

Recommendation #19: The Shuttle Processing Directorate should establish a forum for the core process owners to brief the quarterly and mission metrics packages with Shuttle Processing Directorate management and other core process owners. This is an opportunity for information sharing and integration and may result in a more complete understanding of SFOC processes.

Observation #20: Unless there is a structured, consistent approach to sampling in-family processes, there is no way to validate that SFOC processes are stable, capable, and under control.

The team was repeatedly told that as schedules become more restrictive, the first surveillance task to suffer is the sampling of in-family tasks. Some level of sampling of in-family tasks and procedures is required to support the CoFR. Unless there is a structured, consistent approach to random sampling of in-family tasks, there is no way to validate that SFOC processes are stable, capable, and under control. When combined with the fact that the QAS's are only performing GMIP's and are not able to perform surveillance tasks, there is reason to believe that the SFOC surveillance process conducted by Shuttle Processing Directorate is not as robust as needed. Management needs to re-focus on the importance of the sampling tasks performed by

the Shuttle Processing Directorate engineers and formulate reliable metrics to demonstrate that sampling is performed.

Recommendation #20: The Shuttle Processing Directorate should require the performance of a statistically-based sampling of in-family processes.

Observation #21: The IDO's do not appear to be under a configuration management system.

A major effort associated with the surveillance program is the IDO's, or observations of critical tasks. The IDO's were developed by each engineering organization and the SMA community, and are mandatory for each flow to support the CoFR process. A great deal of effort has gone into identifying the IDO's; however, only those who specified their inclusion know the rationale for the existence of each IDO. There is a need to capture the knowledge and rationale for each IDO to maintain awareness of the need in the future. An annual review of the IDO's should be performed to assure that they continue to be value added. Additionally, a screening process, similar to the process used to remove GMIP's, should be established for the IDO's to determine if any could be eliminated.

The IDO's are controlled by the various organizations that specified their performance. The team learned that it is up to the designating organization to control changes in how the specific IDO is carried out. For the most part, direct observation is required. However, if direct observation by the designated NASA representative is not performed a waiver or alternate method of obtaining the required information is accomplished. In some cases, the alternate method for accomplishing the IDO might be found acceptable for that IDO performance in the future. It is not clear that there is a structured configuration management system to organize the process. The concern is that without structure the IDO's could easily be deleted because the engineering or SMA resource has dwindled to the point that it can no longer be accomplished.

Recommendation #21: The Shuttle Processing Directorate should implement a configuration management structure for the IDO's commensurate with the importance of the IDO's to the surveillance and CoFR processes.

Observation #22: Engineers that are deployed/matrixed to development activities should not be expected to support launch without time to prepare.

Many Shuttle Processing Directorate engineers who are deployed to development tasks are needed on console for launch. These engineers, especially those who are matrixed to other organizations, should not be expected to support launches without adequate time to prepare. Some divisions require the preparation of a flow summary by the engineers who will be supporting the launch; others have no requirement for preparation and it is left to the discretion of the individual engineer. The flow summary includes

significant modifications to the associated subsystem, hardware and software changes, Launch Commit Criteria (LCC) changes, and out-of-family dispositions. This is a good tool for preparing an engineer to support launch; however it does take some time to prepare. The team understood that the flow summary was required in all the process engineering divisions, but the requirement has lapsed in some divisions due to the amount of time required for preparation. There needs to be a consistent approach for launch preparation by those deployed or matrixed to other organizations.

Recommendation #22: The Shuttle Processing Directorate should ensure that there is sufficient time and a consistent approach for launch preparation by those who are brought back from development efforts to support launch.

Observation #23: The Process Integration Division must borrow engineers to staff key positions at the required level for launch.

There are some that believe there are too many people in the Launch Control Center during a launch and there is a need to evaluate the requirement for each person's attendance. Currently the Process Integration Division has identified 17 active positions in launch and landing area for a given launch that require staffing by NASA. These positions include the NTD, the NASA Convoy Commander (NCC), the Landing and Recovery Director (LRD), NASA Safety, and Ground Operations Managers (GOM's) at each of the potential abort landing sites. During the last few launches, the Process Integration Division had to borrow three-to-five engineers from CLCS and other development efforts to support launch. There is a need to review the tasks associated with launch, landing, and recovery operations to determine if any could or should be transitioned to the SFOC, following the appropriate risk assessment.

In years past, there were ten GOM's, covering the TAL sites and the White Sands Space Harbor (WSSH) full time during a mission. The position description calls for a GS-13. To progress in their career, the GOM's move on to other positions in the organization. The combination of travel and workload has resulted in a high attrition rate. It takes approximately one year to adequately train a GOM to cover a site alone during a nominal flight rate; longer given the current low flight rate. There was a plan to eliminate the GOM position and transition the tasks; however, the Office of External Relations and the General Counsel ruled that the GOM was a government function.

There are two active GOM's in the Process Integration Division, with two or three more who are in different jobs and who are qualified to handle the GOM position. It takes up to four GOM's to support each launch. This should also be revisited in light of the projected increase in flight rate from 3-to-4 per year to 7-to-8 per year. Last year, with four flights, the GOM's led all other job categories in having the most lost compensation time and use-or-lose leave than any other classification in the Directorate. There is significant travel associated with the function, mostly foreign. Because of the interaction with foreign governments, the function needs to be performed by a NASA civil servant. Perhaps other government civil servants could perform the function, but it is clear that a

contractor could not. The GOM's also fulfill a project management role by coordinating and contracting for security forces and facility installation, maintenance, and repair. The GOM's are responsible for a $4.0 million annual budget for all sites, and the position of GOM is a full time job for each TAL site. Other than the Astronaut who evaluates the weather at each TAL site, the GOM is the only NASA civil servant on site for launches. The requirement for the GOM, and associated responsibilities, is found in NSTS 07700, Volume VIII, paragraph 4.4.3.1. There is also a need to determine why there is a present need for a GOM at WSSH since there is no foreign government interface.

Recommendation #23: The Process Integration Division should develop a plan for staffing for launch without having to borrow resources from other organizations. If this is determined not to be feasible, managers must assure that those who are brought back for launch are properly trained and have sufficient time to prepare for their launch assignments.

＊Observation #24(a): The establishment of an R&D capability at KSC will evolve over the next five-to-ten years, yet the Shuttle Processing Directorate workforce believes that KSC management wants them out of operations and into R&D immediately. This simply is not true.

＊Observation #24(b): The Spaceport Technology Center concept compliments rather than replaces existing operations, especially operations performed by the Shuttle Processing Directorate.

When addressing the need for KSC to become an R&D Center, there has always been the belief that KSC will never completely withdraw from operations. The establishment of an R&D capability will evolve over the next 5-to-10 years. Yet the Shuttle Processing Directorate workforce believes that KSC management wants them to get out of operations and into R&D immediately. This simply is not true and management has not properly communicated the message. Operational expertise is needed to drive R&D. There is a need to readdress this message and make certain that the workforce knows that this is a long-term project and that all will have the opportunity to provide a contribution.

KSC has a world-class space vehicle processing and launch team with a goal to become a universe-class team by having the expertise to process and launch a vehicle to any destination in the universe. To this end, KSC has implemented a Spaceport Technology Center concept to develop the knowledge and technology that can be applied to any vehicle being processed and launched. The Spaceport Technology Center concept compliments rather than replaces existing operations, especially those performed by the Shuttle Processing Directorate. The value that the Shuttle Processing Directorate provides is the knowledge of what works and what doesn't work. This knowledge, however, needs to be inserted as early in the development process as possible. Too many times in the past, vehicles have virtually shown up at the KSC gate with existing systems, requiring KSC to expend additional resources to modify ground systems to prepare the vehicle for launch. The Shuttle Processing Directorate has been

the repository of the collective launch processing knowledge that exists at KSC today. Shuttle processing expertise is key to the future of KSC and Spaceport Technology Center success.

Recommendation #24: Shuttle Processing Directorate management needs to assure that the workforce understands that the migration to an R&D Center is an evolutionary process that is just now beginning. It is important for the Shuttle Processing Directorate workforce to clearly understand that NASA will never be completely removed from operations. Lessons learned in operations must be transmitted to development efforts.

CONCLUSIONS

The team encourages the Shuttle Processing Directorate to consider all of the recommendations identified above. The team also highly recommends that this report be shared with the workforce who both contributed to the effort and who are keenly interested in its content. Significant among the recommendations are:

* The Shuttle Processing Directorate management team must reinforce as often as possible the tenet that safety is the top priority. The management team needs to clearly state and document the priority of tasks and assure clear communications of priority to the workforce, while maintaining safety as the top priority.

* The Shuttle Processing Directorate must continue face-to-face communications with Center and Shuttle program management to formulate requirements that will be imposed on the Shuttle Processing Directorate in the near- and long-term. Furthermore, the Shuttle Processing Directorate must establish more face-to-face interaction for communications with the Shuttle Processing Directorate workforce.

* The Shuttle Processing Directorate must begin the analysis of how its workforce will evolve in the privatization and commercialization environments and prepare a plan for this evolution. Just as important is the need for the HEDS Enterprise management to provide clear guidance on additional task transition to SFOC, and when the Shuttle program will move to the privatization and commercialization environments. The Shuttle PCA should be modified to reflect the final plan.

* Because the Shuttle Processing Directorate is doing more with less, KSC should corporately determine what the minimum Shuttle Processing Directorate cadre would be to discharge the NASA-retained responsibilities.

* No less important than planning is the attention that must be paid to the needs of the Shuttle Processing Directorate workforce. Where they do not exist, detailed training plans for each position in the Shuttle Processing Directorate must be prepared. Each individual has the desire to grow and have opportunities. Although personal goals may not be aligned with the Shuttle Processing Directorate mission, the

workforce should be offered every opportunity to achieve their individual goals.

❋ Shuttle Processing Directorate management needs to assure that the workforce understands that the migration to an R&D Center is an evolutionary process that is just now beginning. It is important for the workforce to clearly understand that NASA will never be completely removed from operations. Lessons learned in operations must be transmitted to development efforts.

The Shuttle Processing Directorate faces many challenges. The workforce is being asked to perform more diverse tasks with fewer resources than ever before. There are many influences and demands that are out of the control of the Shuttle Processing Directorate management team. The continued uncertainty of the milestones for Shuttle privatization and commercialization makes strategic planning, workforce deployment, and task prioritization difficult. There are simply not enough resources to do all the work that is required. The Shuttle Processing Directorate management team must establish the Directorate's destiny. The management team can only do this through a robust planning process. The evolution of the workforce and processes from today's environment to the privatization and commercialization environments must be analyzed and defined by the Shuttle Processing Directorate; no other organization is willing or able to do this for the Directorate. Modeling of the workforce tasks is needed to demonstrate the level of human resources required to perform the integrated set of tasks. Finally, the results of the planning process must be clearly communicated to KSC Center management, the Shuttle program management, and the HEDS Enterprise management. Organizational expectations need to be clearly documented and agreed upon by all parties involved.

At this time, the Shuttle Processing Directorate is capable of meeting all requirements with the current workforce; however, there are cases where experienced staff are required to leave development activities and return to the Shuttle Processing Directorate to support launch activities. If the flight rate increases, the capability of meeting all the requirements may become a challenge if existing resource shortfalls and demands continue. Note that the capability of the Shuttle Processing Directorate to fulfill its assigned requirements today is based on the ability of the workforce and their individual dedication to making it work.

The processes used by the Shuttle Processing Directorate are deemed stable. This determination is subjective because there are no metrics collected on the NASA-owned processes. It is difficult to determine if the Shuttle Processing Directorate processes are under control. This is primarily due to the fact that there are no metrics on NASA-owned processes. The Process Insight and Trend Analysis (PITA) system is used to collect NASA-generated metrics on the SFOC processes. Although it appears to be uniformly conducted, there are no feedback loops to determine if the PITA process is indeed effective. More needs to be done in this regard.

Our team did not have the opportunity to pursue in detail redundancies among organizations. However, throughout the assessment, our team looked for areas of

obvious overlap or redundancy with other directorates or organizations. Beyond the inherent redundancy among the Shuttle Processing Directorate and SFOC/Ground Operations organizations the team did not find a great deal of redundancy. There appears to be some efforts that could be consolidated across the Center, especially in the facilities design and project management areas and the facilities maintenance arena.

APPENDIX A
Generic Concept for Development of a Comprehensive Training Plan

1. Document Knowledge and Skills Required

   Design documentation, drawings, software applications, operation procedures, contingency procedures, OMRSD, launch commit criteria, etc.

2. Develop Classroom Sessions

   Relay System Design Knowledge, LCC Application Software Knowledge, Applicable Flight Software Knowledge, etc.

3. Develop Standalone Systems Training

   Interactive operational trainers that can demonstrate and test detailed system design and operations knowledge. This is the arena for exercising system specific failure recognition so that integrated training is optimized.

4. Develop Integrated Simulation Training

   Integrated training should focus primarily on the launch team interaction in a real time environment, emphasizing position to position, launch team to flight crew communication and interaction while executing launch procedures. Specific system failures are utilized to initiate the primary purpose of integrated training (i.e., communication and interaction), not for failure recognition as the primary objective. This is handled in Standalone trainers.

5. Develop and document certification requirements that must be met at the completion of the training flow

   This is the time to cross check each training session to ensure that the knowledge or skill required to successfully pass certification has been presented to the employee.

6. Document the training objectives for each phase of training and the time duration required for each position and baseline the training plan.

   The final product will provide the employee with a roadmap to success and the manager with the checklist to ensure certification.

APPENDIX B
Additional Observations/Options

The following are additional observations and suggestions that were gathered through the team's interview process. The team recommends that the Shuttle Processing Directorate review this list to determine if any action should be taken.

- Space Flight Operations Contract (SFOC) concerns:

  The Shuttle Processing Directorate must make certain that SFOC, Ground Operations (GO), step up to their responsibilities and requirements. There is a perception that as long as NASA is around, that SFOC/GO can continue relying on the NASA workforce for support. In addition, some in the Shuttle Processing Directorate workforce are keeping processes that should be transitioned. These self-imposed "mandatory tasks" on the NASA side that are not founded on a requirement place a burden on the Shuttle Processing Directorate workforce that already feels tremendous pressure. SFOC/GO needs to take a leadership role in Shuttle processing, a role that most of the SFOC/GO workforce is not accustomed to assuming. If the metrics are not resulting in a positive change in behavior of the SFOC/GO processes, then the metrics are not worthwhile.

- Checks and Balances

  The agreed-to approach for reviewing out-of-family issues is for the NASA engineer to approve the closure of out-of-family issues, based on investigations led by the SFOC. There is a perception that Shuttle Processing Directorate engineers continue to sign off on all steps toward closure of out-of-family issues and are even leading some of the investigation efforts. Although the team could not definitively determine the validity of these perceptions, further review by Shuttle Processing Directorate management is warranted.

  The most value-added function that the NASA workforce provides is the check and balance. As Shuttle Processing Directorate engineers withdraw from the day-to-day activities, the ability to provide an objective review is diminished. The team is also concerned that no one is evaluating the entire operation. Some people interviewed believe that the NASA/SFOC workforce no longer has the time to assess unexplained anomalies (UA) and in-family problem reports (PR) to determine the impact on the hardware. NASA must make certain that this activity is maintained by assigning engineers to conduct periodic reviews of UA's and PR's as a tool to predict what problems might be developing and to round-out the surveillance program.

- Training Options

  Conduct periodic seminars on the state of technology at KSC, on X-Vehicles and associated technologies, and other pertinent topics. Some interviewed indicated

that they did not have the opportunity to see the technologies of the future to make an individual determination of what skills they needed to perform in the future.

Create computer-based training modules that can be accessed by the Shuttle Processing Directorate workforce when they have time.

In the late 1980's, there was a KSC-wide training program that allowed new hires to get acquainted with the entire Center, not just the area in which they worked. KSC should consider resurrecting this training program. It could also be expanded to allow rotation of new-hires to different organizations at KSC to allow them to get acquainted with the diverse activities that are performed.

- Dealing with a declining NASA workforce/opportunities for a different way of doing business.

The Shuttle Processing Directorate should review tasks associated with the launch, landing, and recovery operations to determine if any could or should be transitioned to the SFOC. A detailed risk assessment should be performed to assure that no significant increase in risk accrues with the transition. Also, there should be Launch Techniques Panels established similar to the Flight Techniques Panel to strengthen the processes. The Launch Techniques Panels should provide forums for the development of flight techniques for processing, launching, and post-landing safing of Space Shuttle vehicle systems.

Option: Consider reinstating retired experts for a week or two to augment the workforce and provide mentoring and training of the younger workforce and new-hires.

- Landing at Dryden/Edwards Air Force Base

It has been a long time since any Orbiter has landed at Dryden/Edwards Air Force Base. The team interviewed several engineers who indicated that regaining the ability to perform a successful recovery of the Orbiter at Dryden may take longer than preparing for recoveries in the past. It was noted that none of the current Shuttle Processing Directorate Orbiter processing engineers have been to Dryden for a landing. A review of this concern should be undertaken with consideration for possibly planning periodic landing simulations at Dryden to assure that all support systems and personnel operate efficiently.

- Shuttle Processing Directorate engineers supporting development at other Centers

There is a perceived lack of respect for the input that KSC Shuttle Processing Directorate engineers can provide to the development and upgrades process led by other Centers. While input is solicited from KSC engineers, it is rarely acted upon. KSC engineers are becoming disinterested in participating because of this attitude by the other Centers. Follow-up by Shuttle Processing Directorate senior

management needs to be done to determine if the recommendations were acted upon by the development organization. If not, the facts should be highlighted to the appropriate Enterprise senior management and to the HEDS Enterprise senior management. The Shuttle Processing Directorate resources are too valuable to be applied but not used.

- Business Objectives and Agreements (BOA) shortfall

  Enabling functions, such as secretaries and administrative positions, were not counted in the Shuttle Processing Directorate BOA. Although these positions are identified on the organizational charts provided in the BOA, they should be included in the responsibility section with the other responsibility descriptions. Failure to do so implies that the people in those positions are unimportant to the organization and their contribution to the total effort is not factored into planning and other activities. The entire philosophy for eliminating administrative support, such as secretaries, has led to already over worked engineers performing administrative duties.

- Industrial Engineering Core Competency

  If the Shuttle Processing Directorate is truly focused on process engineering, some would suggest that there is a need to have more industrial engineers (IE's) that are trained to assess processes. It is the team's understanding that the Shuttle Processing Directorate is able to sustain operations with the current level of resources because the IE's identified areas for process improvement. Currently there are only four IE's in the Shuttle Processing Directorate ranks. IE's are trained to be process oriented, examining processes and determining how to make the production line fail proof. It was also noted that there are several tasks on the retained task list that address industrial engineering tasks.

- Manifest/Flight Rate Dependency

  Interestingly, there are some that do not believe that the Shuttle Processing Directorate is or should be flight/manifest rate dependent. The Shuttle Processing Directorate should have sufficient staff to conduct surveillance in accordance with their plan and to work out-of-family issues as identified; but some say that none of this should be flight-rate dependent. However, as long as the IDO's represent the major portion of the surveillance activity, this activity will always be flight-rate dependent.

- Engineering Discipline

  PITA Sheets and E-Logs replaced the common practice of keeping a personal engineering log. The personal engineering log could be used as the basis for filling out a PITA sheet or making an entry into the e-log. Useful data and insights may be lost if the personal engineering log is not maintained.

- Indefinite Delivery, Indefinite Quantity (IDIQ) Contracting

  It is recommended that the Shuttle Processing Directorate pursue the potential for acquiring an IDIQ contractor. An IDIQ contract could provide a vehicle for acquiring administrative support, training support, and computer software development support for automating PITA and other systems. It could also provide a vehicle for periodically bringing back recent retirees to perform training planning and development and for short-term backfill for engineers on medical/family leave, and provide support for out-of-family resolution. IDIQ contracts are being used extensively throughout the Agency without a long-term funding commitment. Some IDIQ's require only $100,000 per year in payment, with tasks specified and funding negotiated as the need arises.

- Use of Co-op Students

  The use of co-op students to initiate the flow of fresh-outs is extremely beneficial; however, care must be taken to assure that the training and daily assignments are maintained. During the interviews, the team heard two stories about how co-ops are trained. The first training method is to basically assign the co-op student to the SFOC so that the co-op gets the hands-on experience. Although this sounds like a good method for allowing co-ops access to the hardware, there are some difficulties keeping track of the co-op's progress. The second and more effective co-op training method is to assign the co-op to a mentor or mentors and designate a project to allow the co-op to focus on a system or subsystem.

- The team did not find evidence of feedback or evaluation of the SFOC training program, even though the SFOC training program is used in part to train the NASA technician and engineering ranks. The training process is key to the ability of the NASA and SFOC workforce to perform safety-critical tasks. There needs to be a means to measure the effectiveness of the training processes.

- As long as the Shuttle Processing Directorate has to provide concurrence for launch, they will have to maintain knowledge of the process flow. Shuttle Processing Directorate engineers are continuing to perform certain tasks that were either transitioned or eliminated to gain the knowledge to support launch. There is a need to define the boundaries relative to knowledge necessary to concur on launch. Today, the surveillance activities have provided the knowledge about the flow process and disposition of both in-family and out-of-family issues and, therefore, are a significant contributor to the ability of Shuttle Processing Directorate to sign the CoFR. The continued knowledge will only be available if the surveillance activities offer sufficient access to the hardware and flow process. A structured process for reviewing UA's and in-family PR's as a tool to predict what problems might be developing is needed to round-out the surveillance program.

APPENDIX C
Suggestion Concerning Joint Workforces

The Shuttle Processing Directorate assessment uncovered the issue of how to maintain workforce proficiency while withdrawing the NASA workforce from daily operations. Additionally, two related issues include seemingly inadequate workforces on both sides to perform the functions and maintaining the type of job for which the Shuttle Processing Directorate workforce was hired. These issues create a need for an innovative solution to meet the NASA requirements in the future. It is recommended the Shuttle Processing Directorate management pursue the potential for combining the NASA civil service Launch Processing workforce with the USA Launch Processing workforce in a badge-less environment as a method of addressing these issues. On the positive side, this approach would:

- Be similar to the Government Accountable Function (GAF) of Mission Operations employed at the Johnson Space Center. Recognizing that KSC Launch Processing is a Contractor Accountable Function (CAF), but it is believed there are precedents associated with embedding civil service assets into CAF activities as a way of maintaining skills and providing insight/surveillance.
- Have either a contractor or civil service employee provide the same support for launch operations.

For example:
- At transition, the decision was made to create the Contractor Test Conductor (CTC) position as a parallel to the NTD.
- The NTD's and CTC's differ only in the badge that is worn and the processing/launch phases supported.
- The training, proficiency requirements and certification requirements are the same for both. This approach would allow any NTD or CTC to perform any needed tasks increasing the flexibility of the workforce to meet Program needs while maintaining proficiency in both ranks.

Consideration might also be given to using a similar approach with the NASA-SFOC engineering workforce; however, a certification plan would have to be in place to assure equal skills for both the NASA and contractor workers.

By going to a badge-less work environment among the NASA and SFOC workforces at KSC, the combination might allow return to 7 or 8 flights per year with minimal if any additional resources. Proficiency training will be resolved and the Shuttle Processing Directorate workforce would be doing the job for which they believe they were hired. Based on our interviews, this approach would improve morale. Having the Shuttle Processing Directorate workforce embedded would provide leverage for a greater level of surveillance and insight. This approach actually maintains a civil service oversight capability since civil service employees are now doing launch processing. Finally, it provides a larger pool (SFOC and NASA) of operational expertise that can be tapped for new development. It is worthy of consideration.