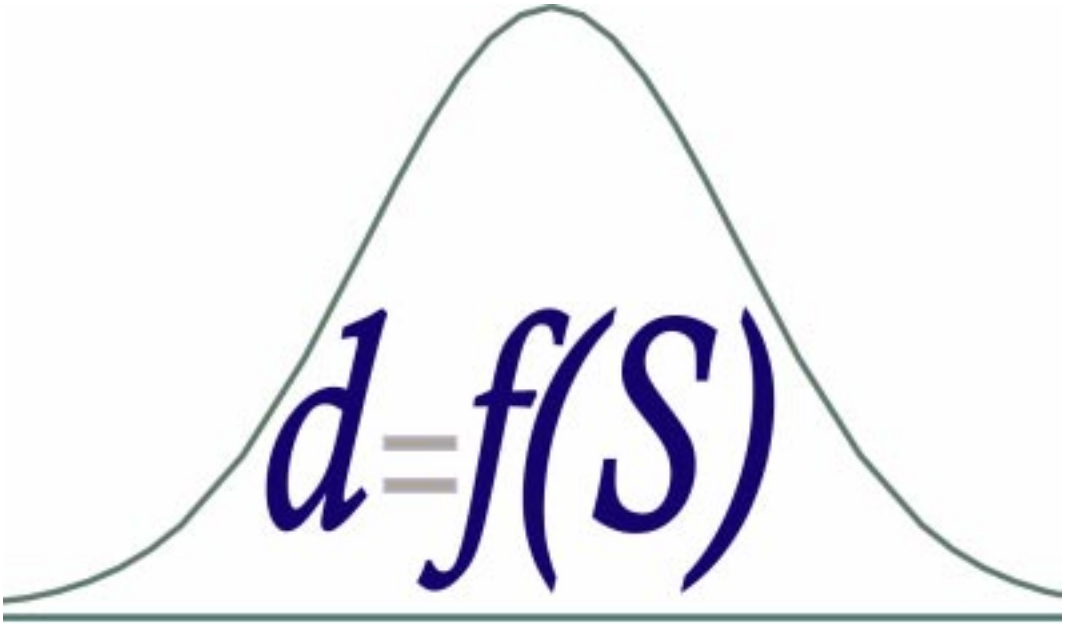
PRACA Enhancement Pilot Study Report

Design for Safety Program

DFS-IC-0006



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Executive Summary

This technology evaluation report documents the findings and recommendations of the Design for Safety Program's PRACA Enhancement Pilot Study of the Space Shuttle Program's (SSP's) Problem Reporting and Corrective Action (PRACA) System. A team at NASA Ames Research Center (ARC) performed this Study. This Study was initiated as a follow-on to the NASA chartered Shuttle Independent Assessment Team (SIAT) review (performed in the Fall of 1999) which identified deficiencies in the current PRACA implementation. The Pilot Study was launched with an initial qualitative assessment and technical review performed during January 2000 with the quantitative formal Study (the subject of this report) started in March 2000. The goal of the PRACA Enhancement Pilot Study is to evaluate and quantify the technical aspects of the SSP PRACA systems and recommend enhancements to address deficiencies and in preparation for future system upgrades.

The PRACA systems and their supporting infrastructure (used to report discrepancies, non-conformances, problems, track engineering dispositions, corrective actions and provide data for trend analysis and reporting) are an essential tool for managing Shuttle safety and readiness for flight. The NASA Johnson Space Center (JSC) PRACA Evaluation Team (PET) was created to address the findings and recommendations from the SIAT, the initial ARC assessment comments, and other SSP sponsored PRACA audits and reviews. The PET was established by SSP Review Control Board Action S060341R5(3-1). The PRACA Enhancement Pilot Study was coordinated with the JSC PET, and as part of a new NASA Initiative – the Design for Safety Program (DfS).

This Study report documents and provides a technical evaluation of the existing and currently operating SSP PRACA systems and quantifies technical and architectural issues. This evaluation then generalizes the technical findings and recommends enhancements to improve this critical NASA distributed information system. The following four areas were assessed for each of the SSP PRACA systems:

- User Interface
- Database and Data Management
- Network and System Architecture
- Problem Reporting Work Processes

A key element of the continuing success of the Space Shuttle Program and the operation of the multiple PRACA systems has been the dedicated and enthusiastic staff of NASA and its contractor team. The progress of this Study was greatly aided by the tremendously dedicated and hard working individuals supporting the Space Shuttle Program. Everyone we spoke to through the course of this Study was highly cooperative and willing to assist us in completing this Pilot Study report and to ensure a continued safe Space Shuttle System.

The overall assessment of the existing PRACA systems is that they are inefficient and potentially vulnerable to data loss and input error. The current approaches do not scale or

adapt easily to changes. The expert knowledge that is required to utilize the PRACA systems is not captured or documented. Overall, the existing PRACA system is incapable of supporting Program-level risk assessment.

Findings

This Study's findings and recommendations support and extend those of the SIAT report. Based upon this overall assessment, the Study presents the following general findings:

1. There is a general vagueness in the definition of PRACA, its intended use, customers, and users that allows the inaccurate impression that the PRACA data systems meet the SSP's needs. The current PRACA implementation shields the SSP from the many deficiencies and weaknesses in the PRACA systems through the use of highly skilled human resources and external data sources upon which the SSP and PRACA depend.

2. The current PRACA systems' technological basis and implementations are insufficient to fulfill Program-level data mining and safety assessment, and to support a Program level of safety, reliability, quality and mission assurance (SRQ&MA) analysis.

   User Interface and Trending

   - User interfaces for all systems are inconsistent or non-existent. The interfaces assume a specific user type that is different across all of the element PRACA systems. This prevents simple navigation across all PRACA systems
   - Trending and Analysis is often performed using non-PRACA systems or only accessing PRACA data as a portion of the data used. This has allowed PRACA to evolve with insufficient data for statistical trending and insufficient supporting information for identifying data relationships in support of data mining.
   - The SSP office and its Project-level management currently meets the necessary condition of having enough problem reporting data and insight by relying on a set of domain experts possessing extensive knowledge of the Shuttle subsystems and the PRACA data. These experts have access to additional non-PRACA data sources and produce consolidated reports and summaries for the SSP from which the SSP performs its tasks and formulates decisions. This is a time-consuming, labor-intensive, and workforce skill-level dependent process. This precludes sustainable consistent processes.
   - For trending and risk analyses, additional data are required to produce results of statistical significance. These data are generated by grouping, or from augmenting databases. Some data are "scrubbed" during reporting to present a "correct" result. Additional data are scrubbed by staff distant from data acquisition and intimate knowledge of the possible reason for the questionable entry.

   Database and Data Management

   - Database schema and data fields collected are incomplete, inconsistent and not structured for data analysis.
   - The different disciplines' definitions of PRACA data field values yield different interpretations across the PRACA systems.

- The United Space Alliance's ADAM data warehouse is a unified store for PRACA data and some associated information but provides no mapping across the various schemas or data field-naming conventions. As a result, queries across the PRACA systems are via an undocumented interface and cannot be extended. This limits any future Program-wide PRACA data mining.
- PRACA is dependent on paper records, printed PRACA forms, and includes instances of re-keyed data. This raises concerns about data transcription errors and data integrity.
- There are multiple data sources on maintenance, repair, corrective actions and engineering dispositions (corrective action reports, hazard reports, engineering databases, expert knowledge, etc.) which are used to generate reports to the SSP but are not cross indexed with PRACA data. This means that a global picture of Shuttle health is not easily accessible.

System and Network Architecture

- Computer system hardware implementations supporting PRACA data management are all unique (some are 20+ years old) and not managed as a Program resource
- Network access to relevant data is difficult due to the location of the PRACA systems throughout the NASA and contractor networks
- Security is incomplete and inconsistent across the implementations. There are inconsistent authorization and authentication processes and no encryption of data during network transfer.
- There is no SSP security policy for system implementation and data protection.

3. A unified "PRACA System" as an organizational/programmatic entity does not exist.
   - The creators and element level managers of the PRACA systems do not view their PRACA systems as Program-wide resources and they have not been required to do so by the NSTS 08126 Revision G document.
   - The WebPCASS and ADAM/IPAS projects under Randy Segert at KSC are consolidating access to the data in many of the PRACA and related systems. However, this system is not being designed for the management or analysis of that data.
   - The element-only focus results in systems that are not useful for Program-wide assessments and data analysis. Each system is unique and engineered for element use only with SSP Office use as an afterthought.
   - The use of the PRACA data as a Program resource to assess the Program-wide safety and risk of the Shuttle is a laborious and time intensive effort taking man-weeks to man-months.

4. The motivation and requirements for the SSP "PRACA System" and its procedures and processes are unknown to the majority of the data providers and collectors.
   - The collectors of PRACA data are largely unaware of the value and potential use of the data gathered. Only a particular subset of data is "known" to be desirable for any given element level PRACA system.

- To a large degree, collecting supporting PRACA data (e.g.. data needed by the SSP for problem background and broad problem documentation to support data mining) are not consistent with efficient workflow and are seen as burdensome requirements.
- Element level training of the use of PRACA data is incomplete. The relative importance in the quality of the data being gathered is not understood.

The JSC PET has rewritten and enhanced the NSTS 08126 document to a Revision H based upon the SIAT concerns and the initial ARC comments. This revision of NSTS 08126 better reflects desired scope and global functions desired of the SSP's PRACA system and clarifies the requirements for PRACA systems. This revision is a necessary step in the enhancement of the SSP PRACA systems. It is expected to be approved in the summer of 2000 by the Space Shuttle Program Review Control Board. We believe that a further clarification of PRACA requirements is still required.

Recommendations

The following recommendations are made to address the above findings, improve the quality, and enhance the use of the SSP PRACA systems:

1. The SSP should clearly define PRACA, its intended use, customers, and users. This should include the operational scenarios and allowable data sources. The SSP should avoid overdependence on domain experts for data analysis and trend report generation.
   - Clearly identify (list) the Program-level PRACA tasks from a Program-wide perspective.
   - Establish requirements for a "PRACA System" that performs SSP level PRACA tasks (data retrieval, mining and trending needs). This action should be performed without consideration of current PRACA capabilities.
   - Design a "PRACA System" that satisfies these requirements.
   - Either a) Implement this new system or b) Initiate a modernization activity to upgrade the current PRACA systems and designs to satisfy the requirements.
   - Enhance the existing WebPCASS proposal based upon the above decisions.
   - Establish a plan for PRACA system evolution that will enable the development of a future Safety and Risk Prognostics capability.

2. Develop and enhance the technical foundations upon which the PRACA Systems have been built. This is critical to enable the creation of a Program-level PRACA system capable of supporting the necessary breadth and depth of SRQ&MA analysis.
   - Enhance the ADAM data warehouse to become a central access point for Program-level SRQ&MA analysis on PRACA data.
     - Develop consistent database schema and structure, and common data field naming conventions and definitions.
     - Schema and structure should be designed to support SSP reporting, trending and data mining applications as well as to support the Project/Element workflow management.

  - Schema and structure should be well documented to preclude data interpretation errors and reporting errors.
  - Standardize on a common COTS database application. Oracle database is most commonly used in PRACA and would be a good choice.
  - Implement standard user authentication across systems.
  - Extend the ADAM data warehouse to include relevant non-PRACA databases.
  - Decrease dependence on external data sources, find out why they exist, and incorporate or cross-index what is needed into the PRACA system.
  - Require that all SRQ&MA reports be generated using these databases to enforce the migration of all necessary data into the "PRACA System."
- Simplify and standardize the user interface to allow ease of data access, cross-system navigation and data analysis with managed knowledge sharing.
  - Implement a standard GUI across all systems. Use a widely distributed and supported web browser as the foundation of this interface.
  - Implement transparency to isolate the user from database to database navigation.
  - Implement a personalizable User Interface allowing customization of the interface to the needs of each user.
  - Provide collaborative capabilities to permit and encourage sharing and queries and analyses.
  - Create data mining and reporting tools to support the advanced SRQ&MA analysts as well as the SSP management level overviews of the data.
- Utilize consistent and accessible secure network and system technologies to protect the data and the user access.
  - Develop a consistent security model for all data, networks, and systems associated with the PRACA System.
  - Identify and establish a security requirements document for the PRACA systems and their data.
  - Eliminate unnecessary data filters and network security bottlenecks.
  - Implement standard system authentication and encryption across systems.
  - Standardize on a common network architecture.
  - Transmit the data on a secure NASA-wide area network implementation.
- Leverage existing data mining tools and expertise to enhance the available trending, assessment, and analysis.
  - Automate repetitively generated reports and trend analyses. Identify ways to codify the labor-intensive procedures.
  - Increase the breadth, depth, accuracy, and speed of PRACA data analysis via advanced automated and intelligent search techniques.

3. Develop a clear set of SRQ&MA trending and analysis requirements. Then develop requirements for the raw PRACA data to be collected to allow the SSP to make risk and safety assessments.
   - Remove the sole dependence on human experts and corporate knowledge for problem assessment.
   - Determine the requirements for Program-wide SRQ&MA view of PRACA data.

- Identify and fix the problems causing data interpretation and "scrubbing" for report generation.
- Require that all Safety and Risk data reports be generated using this system to enforce the migration of all necessary data into the PRACA System.

4. Train and inform personnel in all of the levels of the PRACA system on the processes, motivation and importance of the PRACA data and the system. Analyze the work processes and implement changes to accommodate the SSP PRACA vision.
   - Create end-to-end electronic collection, capture and management of problem reports to reduce PRACA data capture and entry errors.
   - Incorporate PRACA reporting interface use as part of a data collection quality improvement process.
   - Extend the work process assessment to include other PRACA sites, including Marshall Space Flight Center, Palmdale, and the Huntington Beach Problem Analysis Center, and expand the study of JSC and KSC processes to include observational as well as interview data.
   - Re-evaluate the strict hierarchy of problems, based on the tree structure of the Shuttle assembly. This hierarchy makes it difficult to document or describe problems that result from interactions between components in different assemblies or systems.
   - Institute training of technicians and engineers in Program-wide PRACA and what kinds of information are being requested and why.
     - Resolve local differences in how different organizations fill out Problem Report fields.
     - Resolve differences between organizations in how they categorize problems.
   - Determine why there is so much paper movement, and which of it could better be accomplished electronically.
     - Some of the work being done appears to be more easily and accurately done by a computer than by a human.
     - Evaluate the potential for electronic transfer of all documents and the ability to sign the forms on-line with a password protected electronic signature.
   - Determine if, as suggested, a measure of organizational accountability is "the number of problem reports filed."
     - If true, this affects the report classification decisions. This would tend to create a work climate where reducing the number of Problem Reports filed, by tending to identify a nonconformance as a less significant category, has incentive. This would skew the data in the PRACA systems.

We believe that an Agency-wide NASA/Industry team in conjunction with the SSP PRACA workforce can bring together the required expertise, knowledge, and advanced IT capabilities necessary to achieve NASA's Information Management vision for PRACA. In so doing, PRACA will remain a critical and vital system, enabling a reduction in the risk and improvements in safety while supporting the Space Shuttle Program into the next decades.

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1.0 Motivation and Approach

1.1 Motivation for This Study

The PRACA Enhancement Pilot Study was initiated in response to the Fall 1999 review by the Shuttle Independent Assessment Team (SIAT). The first part of the Pilot Study was an initial NASA Ames Research Center Problem Reporting and Corrective Action (PRACA) Technical Review performed in January 2000 at the request of the NASA Code M Enterprise. The initial Technical Review was followed by a more detailed four-month study of the Space Shuttle Program (SSP) PRACA system.

The SSP PRACA systems and their supporting infrastructure are used to report discrepancies, non-conformances, problems, track corrective action, and extract data for trend analysis and reporting. It is an essential system for managing Shuttle safety and readiness for flight. The charter document that describes the requirements for the SSP PRACA system is NSTS 08126, Revision G [ref. 1].

Because of their importance, the PRACA systems have been the subject of several recent reviews aimed at improving the systems utility and improving the motivating requirements. Two of these reviews, the SIAT Report and the initial ARC PRACA Technical Review, are described in the following two sections.

1.1.1 Shuttle Independent Assessment Team Report

In September 1999, NASA chartered the SIAT to provide an independent review of the Space Shuttle sub-systems and maintenance practices. The SIAT published its report in March 2000 [ref. 2]. In the SIAT report, several findings and recommendations were raised specifically regarding the SSP problem reporting practices and systems that may adversely affect Shuttle safety.

1.1.1.1 SIAT Problem Reporting Findings

1. The Problem Resolution and Corrective Action reporting system appears designed from the perspective of data to be kept ("bottom up"), not from the perspective of decisions to be made ("top down"). It does not provide high confidence that all potentially significant problems or trends are captured, processed, and visible to decision-makers.
2. Effective utilization of the Problem Reporting and Tracking system requires specific expertise and experience to navigate and query reporting systems and databases.

3. Missing and inconsistent events, information, and criticality lead to a false sense of security.
4. Tracking and trending tools generally lack sophistication and automation, and inhibits decision support. Extensive "hands-on" examination and analysis is needed to process data into meaningful information.
5. Critical information may be lost and ignored, and problems may be repeated due to weaknesses in reporting requirements, and processing and reporting procedures.
6. The fragmented structure of the Problem Resolution and Corrective Action system, built from legacy systems, minimizes its utility as a decision tool.

1.1.1.2 SIAT Problem Reporting Recommendations

1. The SSP should revise the Problem Resolution and Corrective Action database to include integrated analysis capability and improved problem classification and coding. Also, improve system automation in data entry, trending, flagging of problem recurrence, and identifying similar problems across systems and sub-systems.
2. The root cause(s) for the decline in the number of problems being reported to the Problem Resolution and Corrective Action system should be determined, and corrective action should be taken if the decline is not legitimate.
3. The root cause(s) for the missing problem reports from the Problem Resolution and Corrective Action system concerning Main Injector Liquid Oxygen Pin ejection, and for inconsistencies of the data contained within the existing problem reports should be determined. Appropriate corrective action necessary to prevent recurrence should be taken.
4. A rigorous statistical analysis of the reliability of the problem reporting and tracking system should be performed.
5. Standard repairs on CRIT1 components should be completely documented and entered in the Problem Resolution and Corrective Action system.
6. Reporting requirements and processing and reporting procedures should be reviewed for ambiguities, conflicts, and omissions, and the audit or review of system implementation should be increased.
7. The Problem Resolution and Corrective Action system should be revised using state-of–the-art database design and information management techniques.
8. All critical databases (e.g., Waivers) need to be modernized, updated and made more user friendly.

As a result of the SIAT report, a PRACA Evaluation Team (PET) was established at NASA Johnson Space Center (JSC) by Program Review Control Board Action S060341R5(3-1) [ref. 3]. Several tasks aimed at improving the PRACA requirements and compliance were initiated within each of the SSP's Centers: Marshall Space Flight Center (MSFC), Kennedy Space Center (KSC), and JSC. Several activities were also initiated by the United Space Alliance (USA) to assess internal company PRACA requirements and compliance.

1.1.2 ARC PRACA Technical Review

The NASA ARC PRACA Technical Review was the initial phase of this Study and was a two-week effort at an initial qualitative assessment of the state of the PRACA system. A set of interviews with the SSP's known PRACA stakeholders were held to determine the existing requirements, capabilities, and status of the PRACA system. Upon completion of the review (Jan 18, 2000) a presentation of results was made to the SSP office and the SIAT committee [ref. 7], identifying specific comments, and proposing potential areas of PRACA enhancement.

The JSC PET has used the ARC Technical Review comments and observations as additional criteria to address in their evaluation. The observations attributed from the ARC review were:

1. The Shuttle PRACA system is made up of several parts, which are currently all run independently.
2. There are separate development activities for all PRACA systems (Program and Project).
3. There is no Shuttle Program PRACA owner.
4. The Project PRACA teams do not report to any Program Manager.
5. The functional requirements (i.e.. what information must be tracked) for the PRACA systems come from two places.
    a. Only the SSP Office document NSTS 08126 Revision G defines the flight critical information to be tracked.
    b. The separate Center Projects and requirements exist at JSC, KSC, and MSFC that support the Shuttle Program. These are non-consistent requirements (i.e., they are not in conflict, but they are not necessarily complimentary).
6. The integration of the various PRACA data from the Center Projects is integrated into two Program accessible systems; the old system is the Program Compliance Assurance and Status System (PCASS); the new system is called ADAM and is proposed as the basis for WebPCASS.
7. There is no schedule or milestones for transition from PCASS to ADAM.
8. There is no Shuttle Program owner or user of ADAM.
9. Extensive knowledge of the PRACA systems and desired data is required for efficient operation and queries.
10. Four particular areas could be assessed and improved;
    a. Front-end user interface for searching, displaying, and analyzing the PRACA data;
    b. Database and system infrastructure for storing/accessing the PRACA data from the various Center systems;
    c. Problem reporting processes for capturing PRACA data;
    d. Requirements and management for Shuttle Program Office PRACA.

A new NASA Initiative, Design for Safety (DfS), was launched simultaneously with the release of the SIAT report. The PRACA Enhancement Pilot Study was started by NASA within the DfS Program to understand and detail the PRACA issues and recommendations raised in the SIAT report. The primary goal of this Pilot Study is to evaluate and quantify the technical issues with the current implementations of the SSP PRACA systems and recommend high value enhancements to address deficiencies and enable a future Safety and Risk prognostics capability.

1.1.3 The Creation of the SSP PRACA System

In 1987, after the Challenger accident and in response to the Rogers Commission recommendation to provide NASA Space Shuttle management and decision makers with readily available, timely, and accurate data, the PCASS was formed. The PCASS is defined in document "System Integrity Assurance Program," NSTS 07700 Volume XI.

The NSTS 07700 document section 3.4 states that all Shuttle nonconformances, including unexplained anomalies, shall be documented and transmitted to the design project elements for investigation and resolution in accordance with the requirements of NSTS 08126. PRACA data and status shall reside in or be accessible via the PCASS as specified in NSTS 07700 vol XI, section 4.1.x.

The NSTS 07700 goals were to impact Shuttle processing, safety, and readiness for flight by enabling continuous process improvements. The PCASS-hosted overall "PRACA System" would allow users access to the current and historical data necessary to perform trend analysis and reporting to aid in the process planning and improvement. To provide the data necessary for this Program-wide "PRACA System," currently a combination of paper records, on-line databases from separate PRACA systems, and corporate/expert knowledge and skilled personnel are required.

The PCASS is being replaced by an updated web-based version called WebPCASS. It is being proposed as a straightforward re-hosting of the mainframe-based PCASS onto a Unix server with a browser interface. The NSTS 07700 goals of an interactive Shuttle data store for use in trending, safety and reliability analyses are not yet being realized.

1.2 Assessment Approach

The objective of this Study report is to document a quantitative assessment of the technical and operational status of the SSP PRACA systems and elements. This quantification is intended to enhance the initial ARC Review's 1-month qualitative assessment (completed in January 2000). In addition to the "as-implemented" aspects, the team desired to understand the "as used" issues and challenges with the PRACA systems so that any recommendations, while technically feasible, can also be evaluated for their practicality and work environment utility.

The approach taken by the Study team was to interview, understand, and assess. This approach required multiple site visits, telecons, and interviews with as many of the people involved in the PRACA system as possible (managers, users, customers, etc). The team consistently noted the support and cooperation by the NASA and contractor staff throughout the SSP PRACA system. This was fairly unique in the team's experience to see such cross-center cooperation and enthusiasm for progress towards a common goal. All of the team's requests for information, documentation and time were professionally addressed and met the team's needs. A summary list of contacts, sites, and interviews is provided in the Appendix.

Through the course of our Study, the team continually coordinated its activities with the JSC PET. Specifically we kept Ms. Linda Ham, supporting Mr. Ronald Dittemore; Manager of the Space Shuttle Program, appraised of our status, observations and findings.

The quantitative technical assessment began in March 2000. The Team visited and interviewed PRACA systems owners and users at JSC, KSC, and MSFC. The purpose of these meetings was to understand how the SSP elements collect, manage, and use the problem reporting data. The team also interviewed multiple safety, reliability, quality and mission assurance users of the PRACA data to determine the desires and implicit requirements for the PRACA systems. As part of the interview process, the team collected available system documentation recommended by the contacts and thought to be of value to the study.

Based upon the SIAT report findings, and to simplify the organization of the report, the team decided to group the PRACA system technologies into four primary technical areas. These four areas are:

1. User Interface
2. Database and data management
3. Network and system architecture
4. Work processes of Problem Report generation and use

The focus of these areas is described in greater detail in the following sub-sections.

1.2.1 User Interface Assessment

Because of the SIAT emphasis placed upon increased access and visibility into the PRACA data (i.e., broader NASA and Shuttle user community access, access to greater detail and supporting data, need for cross PRACA data mining, increased user-friendliness, etc.) the user interface was chosen as a primary technology area of study.

The user interface was studied from several user perspectives:

- The PRACA system data manager and administrator. For this user, database administration, data security, entry, management, and control are the primary interface uses.

- The SRQ&MA user. This user's main interests are to produce knowledge and conclusions via data extraction, reduction, analysis and trending. For this user, the interface is a tool to simplify navigation of the databases to find the obvious and not-so-obvious relationships and to assist in the generation of meaningful reports.
- The engineer/researcher interested in process and procedure improvement. This user is typically looking for hidden trends and data relationships, or is performing detective work. The user requires an intuitive way to navigate the data and follow links between databases to uncover otherwise "hidden" data trends. This user is typically the one to uncover or preclude the "escapes" and "diving catches." This user requires an interface providing data mining and drill down capabilities with advanced analysis recording and sharing methods.
- The high-level manager. This user is primarily interested in fast and easy access to bottom-line conclusions, current and historical summary information and trend reports. For this user, the interface is used to navigate a report archive.

The team interviewed the various user types and used and evaluated the various PRACA systems interfaces where possible. In the case of the JSC government-funded equipment system and the KSC group support system, the team did not achieve hands-on access, due to the team's remote location exclusion from the firewall-protected LAN (security model) and the user interface being designed for local access only.

1.2.2 Database and Data Management Assessment

The quality of PRACA system data analysis and conclusions are dependent upon data integrity, quality, ease of access, and cross-system data query for full leverage of PRACA. Because of this, the Database design and implementation was chosen as a primary area of study. To perform the database assessment, the team considered many aspects, including:

- Database application (relational, object oriented, web enabled, query languages supported).
- Architecture or schema (tables, objects, multimedia capability, text treatment, entity-relations model, etc.) The team requested the database schema or design documentation, when available, and the naming conventions for the data fields.
- Administration and data entry. The team determined the methodology for entering data into and retrieving data from the database, user management and access control, as well as the query methods and consistency across systems.

No detailed assessment of the database software performance upon the computer systems was made at this time.

1.2.3 Network and System Architecture Assessment

The highly networked NASA and aerospace community, increasing breadth of internet communication methods (text, audio, video), new network security models, and advances in system architectures and performance, compelled the team to select network and system architecture as the third primary area of study. The team considered many aspects including:

- Server technology
- Network security implementations (firewall, proxy, trusted host, etc.)
- Center-to-center communication techniques
- Technology maturity levels relative to state-of-the-art.

1.2.4 PRACA Work Process Assessment

The final primary area of study selected by the team was the PRACA work process. The team chose this area in an effort to ensure that its IT recommendations are consistent with the practical aspects of the real work environment. Work process assessment in this Study was limited to two PRACA sites: on-site tracking and interview of the KSC PRACA data collection, and JSC Orbiter problem reporting closure processes. The team believes this preliminary assessment of two PRACA centers demonstrates the utility of a work process study and that a more detailed assessment can be performed in the future at additional PRACA sites.

To perform the work process assessment, the team began by performing a series of interviews at JSC and KSC to obtain an initial analysis of relevant work process and work flow issues. The PRACA work process assessment focused on the KSC PRACA data collection, and JSC Orbiter problem reporting closure processes. Follow-on assessments should perform observations of the actual process of PRACA reports being initiated, dispositioned, filed, transferred, and used.

1.2.4.1 Work Process Assessment at JSC

Interviews at JSC were focused on two levels. First the team investigated the databases to determine how they are used. Second, the team investigated how the organizations that support and use these databases interact. This includes the relation between the Space Shuttle Vehicle Engineering Office (which has the final say on Shuttle flight constraints) and the Orbiter PRACA database (whose database is owned by USA and whose work process and front end are owned by Boeing). It also includes the JSC Government Flight Equipment (GFE) database. In addition, we interviewed members of the Shuttle Safety Assurance and Mission Assurance office. In these interviews, we attempted to determine the flow of information through the PRACA system, and the perspective of the users in each area.

1.2.4.2 Work Process Assessment at KSC

Interviews at KSC were designed to focus on the process by which a problem is discovered and a PRACA problem report is filed. The team attempted to determine the exact work of filling out the form for a problem report from the initial discovery of a nonconformance to final closing out of the report in the database.

2.0 State of the SSP PRACA System

This section details the state of the SSP PRACA systems. This information was collected from the interviews with various PRACA system owners and the Project/Element level and analysis of available PRACA documentation.

2.1 PRACA System Overview

The Space Shuttle PRACA systems and their supporting infrastructure are used to report discrepancies, non-conformances, problems, track corrective action, and extract data for trend analysis and reporting. It is an essential system for managing Shuttle safety and readiness for flight. The charter document that describes the requirements for the SSP PRACA system is NSTS 08126, Revision G [ref 1].

2.1.1 PRACA Requirements from NSTS 08126 Rev. G

The NSTS 08126 Revision G document was signed on February 2, 1996. That document provides the minimum requirements and responsibilities applicable to all SSP PRACA systems, as required by NHB 5300.4(1D–2), Safety, Reliability, Maintainability and Quality Provisions for the SSP. The objectives of NSTS 08126 Revision G are to:

a. Establish uniform standards to ensure safety, reliability, and quality of SSP.
b. Establish the requirements/procedures to assure problems are dispositioned prior to flight.
c. Ensure appropriate corrective action is taken in a timely and cost effective system.
d. Provide the problem data necessary to support engineering analyses and logistics management.

The NSTS 08126 Revision G does not address the issues or requirements for extracting the data necessary for trend analysis and reporting. While it does provide the data for engineering analyses and logistics, this has not proved sufficient to the SRQ&MA analysts and has necessitated having adjunct data sources and databases to perform risk and reliability trend analyses.

NSTS 08126 Revision G has established some uniform standards for ensuring safety, reliability, and quality of SSP, but has not required or documented the critical

information and data standards. These include data management standards, such as field naming and database schema, that would enable the development of common SSP-wide PRACA data systems. Such a system is discussed in the recommendations, and is what the current implementation of the SSP PRACA lacks. The use and design of the existing PRACA systems, described in the following sections, points to the innate desire of the SSP for a unified access to PRACA data.

2.1.2 Implementation of SSP PRACA

The current SSP "PRACA System" is a collection of computer hardware, software, networks, and databases, as well as extensive paper files distributed across several NASA, USA and other contract support sites. These separate PRACA systems are managed by various teams of individuals whose job is to maintain the systems, keep the databases current, and assist in the extraction of data for trending and reporting. One of the key components contributing to the success of the current PRACA systems is this support staff that forms the extensive corporate and institutional knowledge necessary to analyze, reduce, produce conclusions, and report results from the PRACA databases. Without these highly trained and expert staff, the utility of the PRACA data is reduced significantly.

The data management capability behind the SSP PRACA System is a conglomeration of Project-level database systems to meet today's Program-level requirements. Many of the component systems are designed as workflow management tools with strict requirements for streamlining accurate and timely problem resolution. Other systems are focused upon capturing the problem report data at a high fidelity useful in safety analysis and data mining applications. It is these two dissimilar requirements (workflow efficiency vs. extensive problem documentation) that are at odds in the current SSP PRACA systems.

For the purposes of SSP use, the PRACA system is viewed as a collection of domain-expert managed systems. At the time of this Study most of the data from all but one of the Project PRACA systems could be queried through a centralized data warehouse (ADAM) for summary and condensed report viewing. However, as noted by the SIAT, ADAM cannot be data mined or navigated by the non-expert user. As a result, the SSP uses the PRACA systems principally by contacting the appropriate responsible domain experts and requesting that a report or data trending exercise be produced for the Program office. Then, a team of domain experts at JSC, KSC, MSFC and other support sites accesses the PRACA component databases, other experts, additional off-line databases, and paper records to produce a report for SSP. These reports are usually placed in the PRACA systems and become part of the on-line record. It is important to note that reports of any sophistication (i.e., data mining, detailed cross PRACA correlations etc.) cannot be generated in real time using the on-line PRACA systems alone.

The primary component systems and the information flow from the SSP expert centers are shown in the figure below:

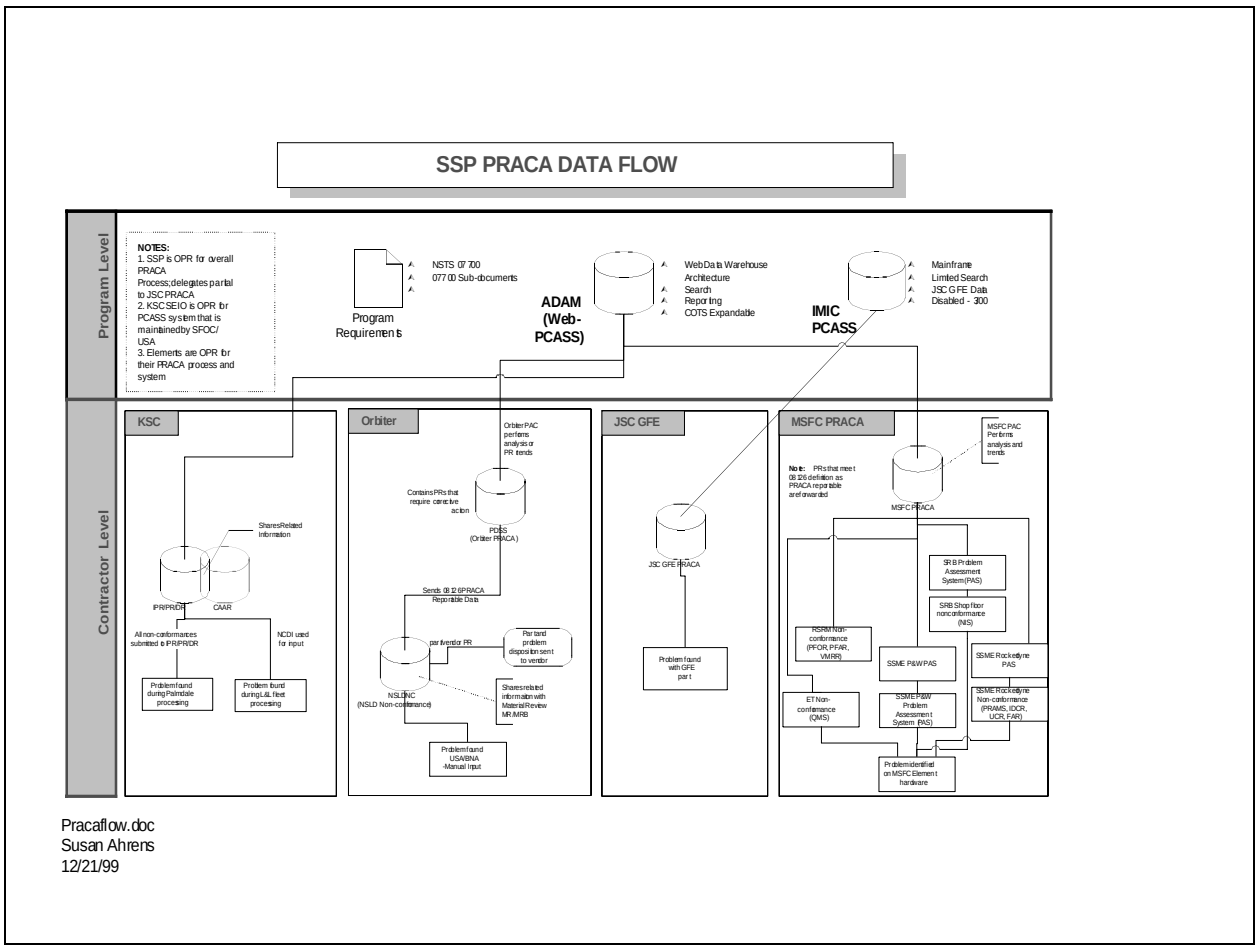

Figure 1 - SSP PRACA Data Flow [S. Ahrens]

2.2 State of the System (Spring 2000)

In this Study we have identified four operational element PRACA systems and a fifth nascent Program-wide system. They are:

- JSC's Orbiter PRACA Data Support System (PDSS)
- JSC's Government-Furnished Equipment PRACA system
- MSFC's Problem Assessment System
- KSC's Shuttle Problem Data Management System
- USA's Advanced Data Acquisition and Management system for PRACA Data

2.2.1 JSC Orbiter (PDSS)

The JSC Orbiter PRACA Data Support System (PDSS) tracks all reportable problems that occur on hardware for which JSC has design responsibility. PDSS provides the primary source of data used by the Program SR&QA Trending and Analysis group (JSC Code NC and SAIC). Using the PDSS the JSC Problem Action Center team can access more than 55,000 Failure Records which includes the over 20-year history of Incoming

Messages (IMs), Suspect Problem Reports (SPRs), Corrective Action Records (CARs), and Non-Flight Constraints (NFCs). The PDSS summarizes failure history, performs trending analysis and provides management with visibility through sorted reports.

The PDSS PRACA requirements are documented in "Procedures for Orbiter Problem Reporting and Corrective Action (PRACA)" USA document PAC-2718283 (Revision B). The PAC-2718283 document applies to all elements and sites involved in the manufacture, assembly, handling, use, testing, or repair of any Orbiter component, Shop Replaceable Unit (SRU), or Line Replaceable Unit (LRU). It is specifically applicable to the USA's prime contractor and subcontractors. It also includes Ground Support Equipment (GSE) for which USA has design responsibility.

As with all PRACA systems, overall requirements for establishing a closed loop problem-reporting system are documented in NHB 5300.4(1D-2) Safety, Reliability, Maintainability and Quality Assurance Provisions for the Space Shuttle Program. The Level II requirements for implementing this system are defined in NSTS 08126, SSP PRACA System Requirements.

A summary of the PDSS specifications and key information are shown in the table below:

System Name:	Orbiter PRACA, PRACA Data Support System (PDSS)
Point of Contact:	NASA: David Brown Contract: Suzanne Little (USA)
Location:	Primary system: NASA JSC Support sites: Palmdale, Downey, KSC, and NSLD, MSFC
Operational Since:	More than 20 years. PDSS contains data from as early as 1974. The GFE data was originally part of the PDSS database. GFE was established as a separate database in the 1997-1998 time frame. In 1998 the database was upgraded to Oracle.
Purpose:	Tracks all reportable problems that occur on hardware for which JSC has design responsibility
Platform:	IBM PC Compatible
O/S:	WinNT 4
Database:	Oracle 7 (upgrade from DB2)
Application Programs:	Client App: Gupta SQLWindows DB Management: Integrated Database Application (IDA) (custom) Reporting: Trendtool (custom software)
Security Model:	Primary: Firewall Protected Intranet. (Mirrored at USA and Boeing for intranet access) Passwords/UID: Read: None, Write: User and Password required
Requirements Document:	NHB 5300.4 (1D-2), NSTS 08126, PAC-2718283 (updated to Revision B on May 22, 2000)
Web Info:	http://www.houston.ssd.bna.boeing.com/d331/pac/mainpdss.htm

Table 1 - JSC Orbiter System Information

2.2.1.1 Architecture

The PDSS has followed the Space Shuttle development with the earliest data in PDSS originating in 1974. The first version of what was to become the SSP PDSS was created by Rockwell (though earlier versions may have existed for the Apollo Program). With contract changes, the system moved from Rockwell to Boeing ownership, then to its current owner, Boeing-USA. The PDSS originally contained the GFE database information. Most GFE data were removed from PDSS three years ago when the decision was made to separate task management of NASA-owned GFE from Program-owned (and thus USA-managed) GFE. The GFE owned by the Orbiter Project office remains in PDSS while NASA-owned GFE is managed in the GFE database (discussed in the next section).

2.2.1.1.1 System

The PDSS database is housed on a single IBM-compatible computer system (the Host) running the Windows NT operating system located at the NASA JSC Boeing-USA facility. The computer system runs the Oracle 7 relational database application and can support multiple databases and several simultaneous users. This Host system is connected to the NASA JSC Firewall Protected Local Area Networks (LAN). There are no passwords or User ID required for read access but valid User and Password are required for write and administration access. For increased user community access while maintaining the network security model, a second database system is mirrored at the USA facility.

The client machines access the PDSS database by running a Gupta Corporation SQLWindows-based application developed by the Boeing-USA PDSS support group. The data can be queried and reports generated from either the Host or the authorized client computers. Database management requires user and password authentication and can be performed on the Host or trusted client systems within the firewall-secured LAN.

2.2.1.1.2 Network

PDSS PRACA is implemented on the JSC internal web, which is protected by firewall security. The host allows specific computer connections via a client access table managed in the Host computer. Access at firewall-separated LANs is currently managed by mirroring the system across the firewall. The system and user access tables maintained in the Main Host computer provide access control. There is no encryption of the data as it is sent across the network. User management is independent of the other SSP PRACA systems and is managed locally by the PDSS group.

2.2.1.1.3 Database

The Orbiter database was originally implemented in DB2 [ref 11]. The PDSS utilizes several process models and a single database. The Orbiter PRACA process models

include process flows for the initial CCAR/TCAR decision and the subsequent processing of these problems. The database uses twelve primary tables with several additional tables to support applications processing and codes. There is one entry in the common table for each problem record. There are repeating entries in five other tables for each problem record. There are six tables that contain narrative text information. The field JSC_REPORT_# is the unique identifier for each problem record and exists in each table.

The system was transition to the Oracle 7 relational database in 1998 during the extraction of NASA-owned GFE data (and simultaneous creation of the GFE database). The basic twelve relational table design has been preserved while adding additional support tables.

System management is currently performed using custom software called the Integrated Database Application (IDA). The IDA controls data input to PDSS through required input fields and checks the inputs against allowable tables. The IDA ensures data entry is complete and accurate. Access is limited to the Problem Action Center by firewall, system, user and password authentication. Approximately 5-6 people currently have such access. The current size of the database is approximately 5 GB.

2.2.1.2 Data Collection

The data collection process is described in PAC-2718283 (rev B) "Orbiter Problem Reporting and Corrective Action". The data collection process flow is illustrated in the figure 2 below:

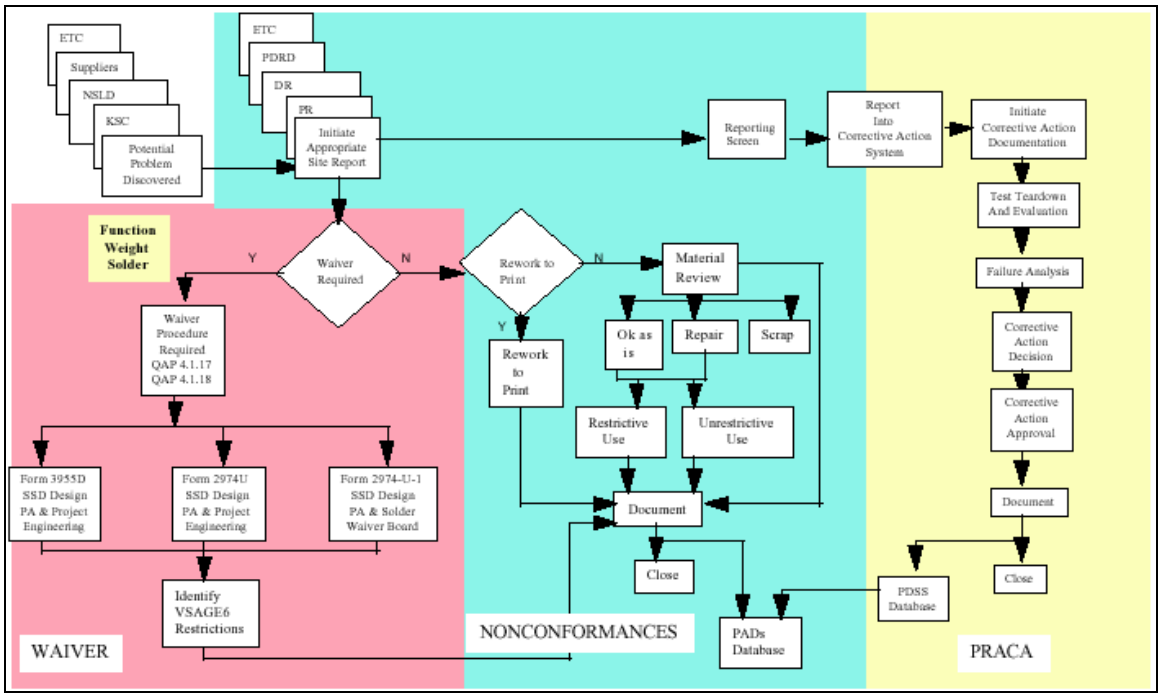

Figure 2 -NASA JSC Orbiter Nonconformance/PRACA Process Generic Flow

Database entry is limited to the Boeing Product Assurance Problem Action Center. The Problem Action Center was chartered in compliance with the provisions of NASA NHB 5300.4 (1D-2) and the implementation requirements of United Space Alliance (USA), "to facilitate an ongoing centralized system for the timely reporting of significant Orbiter Hardware nonconformances and to administer the resultant problem reports until adequate Boeing disposition can be accomplished in support of the Space Shuttle Operational Program."

The Problems being reported into the PRACA system through the Problem Action Center include significant pre-ATP and ATP failures occurring at suppliers and Boeing manufacturing facilities:

- During supplier and/or Boeing certification/ qualification testing;
- At Boeing facilities and the NASA test and Operational centers during ground test, In-Flight, turnaround and overhaul; and
- During repair operations or shipping and receiving to or from repair depots.

The failed hardware includes flight hardware, like-flight hardware, spares and safety-critical ground support equipment.

2.2.1.3 Interface

The PDSS summarizes failure history, performs trending analysis and provides management with visibility through sorted reports. The system can be queried for data ranging from general trend studies to specific failure history searches for individual part names, part numbers, serial numbers and selected causes of failure. The data in PDSS are accessible via custom client applications written using Gupta SQLWindows. These applications are provided by the PDSS support group and run on IBM PC compatible computers with the Windows OS environment. The PDSS support group is currently looking into implementation of a fully web-enabled interface.

The PDSS supports a custom reporting and trending application called "Trendtool." Trendtool is a windows-based menu-driven, on-line, interactive application that provides access to trending capabilities for engineering analysis. Its capabilities include on-line viewing, printing, interactive plotting and electronic file generation.

In addition, the JSC Problem Action Center (PAC) generates weekly reports reflecting PRACA status. Prior to each launch, management is furnished with the L-10 through L-1 day report daily, identifying all open issues pertaining to the launch. The PAC maintains a distribution list for these reports. The PAC established a PRACA web page to provide open access to PRACA documents, reports, and procedures. The PRACA web page is maintained by the PAC-Houston Operation and may be viewed at:
http://www.Houston.SSD.BNA.Boeing.com/D331/PAC/MainPDSS.htm

2.2.2 JSC Government-Furnished Equipment (GFE) PRACA system

The Government-Furnished Equipment (GFE) PRACA database is another essential component system for the SSP's PRACA data. The GFE system tracks all reportable anomalies and non-conformances detected on JSC GFE flight hardware, and equipment that is representative of flight hardware. The primary contractor for support of this system is SAIC.

The GFE PRACA requirements are documented in JSC 28035 (currently under revision). As with all PRACA systems, overall requirements for establishing a closed loop problem-reporting system are documented in NHB 5300.4(1-D2) Safety, Reliability, Maintainability and Quality Assurance Provisions for the Space Shuttle Program. The Level II requirements for implementing this system are defined in NSTS 08126 Rev. G.

Key system information is presented below:

System Name:	Government-Furnished Equipment (GFE)
Point of Contact:	NASA: David Dyer Contract: Scott Ferguson, (SAIC)
Location:	Primary system: NASA JSC Support Sites: none
Operational Since:	GFE contains data from as early as 1974. The GFE data was originally part of the Orbiter PRACA database. GFE was established as a separate database in the 1997-1998 time frame.
Purpose:	Tracks all reportable anomalies and non-conformances detected on JSC GFE flight hardware, and equipment that is representative of flight hardware
Platform:	IBM PC Compatible
O/S:	WinNT 4
Database:	Microsoft Access 97
Application Programs:	Client App: Runtime version of MS Access 97 DB Management: MS Access 97 (Main Host only) Reporting: MS Access 97 (Client and Main Host)
Security Model:	Primary: Firewall Protected Intranet. Machine level access table maintained on Main Host Passwords/UID: None
Requirements Document:	NHB 5300.4 (1D-2), NSTS 08126, JSC 28035 (currently under revision)
Web Info:	None Available
Other:	The GFE database provides support for both the SSP and ISS programs. Data for both programs reside in the same database. Program data are distinguished by the "ProgramAssignment" field.

Table 2 - JSC GFE System Information

2.2.2.1 Architecture

The GFE database was originally part of the Orbiter PRACA system (as described in the section above on PDSS). Like PDSS, the GFE data has followed the Space Shuttle development with the earliest data in GFE originating in 1974. The GFE data were separated out of Orbiter PRACA during the PDSS Oracle upgrade in the 1997-98 time frame. This upgrade left two separate data systems (GFE and PDSS) resulting in separate data management responsibilities. The GFE database contains information about NASA-owned GFE, while the SSP-owned GFE is tracked in PDSS.

In addition, the GFE database design supports both the SSP and ISS programs. Though the data from both programs occupy the same database tables, the database architecture allows for managing and retrieving each program's data separately and presents no apparent operational problems.

2.2.2.1.1 System and Network

The GFE database is housed on a single IBM-compatible computer system (the Host) running the Windows NT operating system. This host runs the Microsoft Access 97 relational database application and can support multiple databases. The host is connected to the NASA JSC firewall-protected LAN and allows connections via a client access table. The clients access the GFE database via a run-time version of MS Access 97. The data can be queried and reports generated from either the host or the authorized client computers. Database management is performed on the host system directly.

2.2.2.1.2 Database

The GFE database is implemented in the Microsoft Access 97 database application. The database architecture has 12 primary tables (Common, PARTS, REC_CNTL, REL_DOCS, REV_SETS, SRA_SETS, Tbl_DeferralRationale, Tbl_DeferredStatus, Tbl_DRNumber, Tbl_FMEANumbers, Tbl_Remarks, Tbl_TPS). The 12 tables are legacy architecture from the original DB2 design of Orbiter PRACA. All tables share the common field "rept_no". Additional Access database tables contain codes and support information.

The populated GFE database size is currently ~ 100MB. There is no indication that GFE will outgrow available disk capacity.

2.2.2.2 Data Collection

The data collection process for GFE is described in the "JSC GFE PRACA Process" document authored by SAIC's Scott Ferguson. When a nonconformance is determined to be PRACA reportable, the appropriate personnel initiate a PRACA report with a unique control number. The PRACA report is delivered to the JSC GFE PRACA Center (JGPC). The JGPC is responsible for distribution of the PRACA reports to the appropriate

personnel, filing the appropriate forms (e.g., JF 2174E, JF 2174G, JF2174H, contractor reports, etc) and entering/updating the information into the JSC GFE PRACA database.

The process is shown in the flowchart presented below:

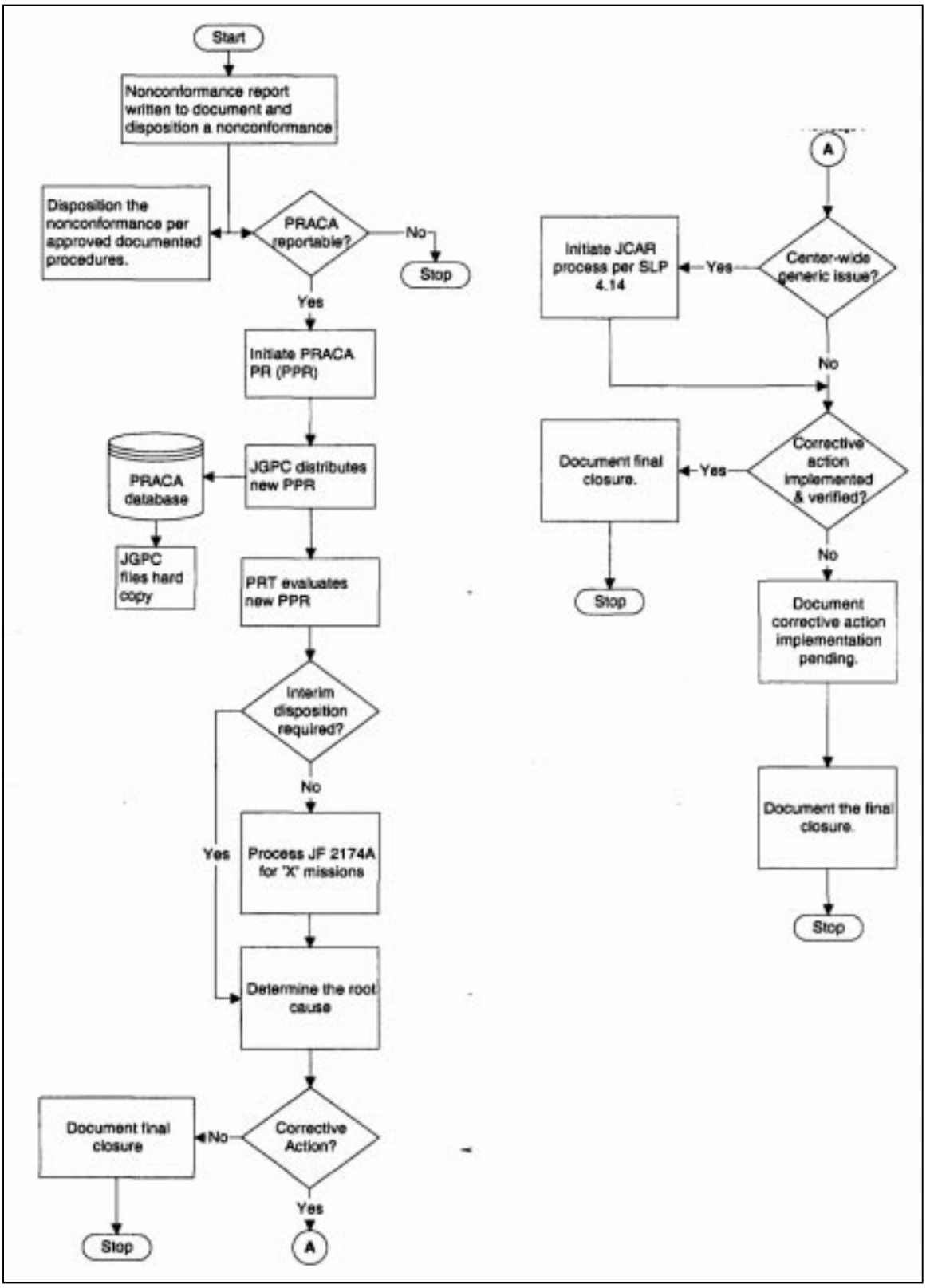

Figure 3 - JSC GFE Data Collection Process Flow [S. Ferguson]

2.2.2.3 Interface

The trusted client machines access the GFE database by executing a run-time version of MS Access. The reporting and data query interface uses the MS Access GUI environment. The data can be queried and reports generated from either the Host or the authorized client computers. Database management is performed on the Host computer via MS Access directly.

2.2.3 MSFC Problem Assessment System

The MSFC Problem Assessment System is operated by Hernandez Engineering Incorporated (HEI) and reports to the MSFC Safety and Mission Assurance (S&MA) Problem Assessment Center.

The MSFC PRACA requirements are documented in QS10-R-005 Revision B and the MSFC Problem Assessment Operations Plan, and the MSFC Problem Assessment Center Operating Instructions. The overall requirements for establishing a closed loop problem-reporting system are documented in NHB 5300.4(1D2) Safety, Reliability, Maintainability and Quality Assurance Provisions for the Space Shuttle Program. The Level II requirements for implementing this system are defined in NSTS 08126. The MSFC PAS also is responsive to the ISS 30223 document - Problem Reporting and Corrective Action System Requirements for the International Space Station (http://iss-www.jsc.nasa.gov/cgi-bin/pals/docchk?52829).

Key Information about the MSFC PRACA system is presented in the table below:

System Name:	Problem Assessment System (PAS) a.k.a. UPRACA
Point of Contact:	NASA: Alex Adams, QS-20 and Don Whirley, QS-10 Contract: John W. McPherson (HEI)
Location:	Primary system: NASA MSFC Support sites: MSFC, JSC, KSC
Operational Since:	The MSFC Problem Assessment Center began in 1978
Purpose:	Tracks all 08126 PRACA variables reported from SSME, ET, RSRM, and SRB
Platform:	Sun Server 300 MHz, 1 Gbyte of RAM, 33.6 Gigabyte HD space available
O/S:	Solaris Version 2.6
Database:	Oracle v 7.3.0.2
Application Programs:	Client App: written in C v 4.2 (custom SW) DB interface: embedded SQL in C program Reporting: HTML generation by C program
Security Model:	Primary: User authentication and NASA IP restricted web-site Passwords/UID: required for UPRACA data access

Requirements Document:	NSTS 08126 QS-10-R-005 rev B NHB 5300.4 (1D-2) NAS8-40364, DR 9 ISS 30223
Web Info:	MSFC Problem Assessment Center Page http://msfcsma3.msfc.nasa.gov/tech/pac/s_mapac.html MSFC UNIX PRACA Data System http://upraca.msfc.nasa.gov:8018/praca/review/public/html/index.htm
Other:	Tracks SSP, Station and several other MSFC projects

Table 3 - MSFC PRACA System Information

2.2.3.1 Architecture

The MSFC processing of Shuttle hardware prime contractor PRACA reportable problems is performed by a combination of civil service and contractor personnel within various organizations. This process flow is applicable to MSFC processing of External Tank (ET), Reusable Solid Rocket Motor (RSRM), Solid Rocket Motor, (SRM), and Space Shuttle Main Engine Problems.

The element hardware prime contractor is responsible for problem reporting, statusing, and correction. These requirements are defined in the contractual documents between MSFC and the contractors. The MSFC Problem Assessment Center (PAC) runs the Problem Assessment System (PAS) as part of the Safety and Mission Assurance (S&MA) support services contract. The PAC does the following:

- Receives the problem reports in the prime contractor format;
- Reviews and validates the data for accuracy, clarity, consistency, and completeness, seeking additional data as required;
- Translates the prime contractor data into the standard data field of the MSFC PRACA system (UPRACA) and the NSTS 08126 defined data fields;
- Enters (re-keying and/or reformatting) the data into the PRACA database;
- Facilitates the dissemination of the problem reports to the appropriate MSFC offices;
- Monitors the compliance of the prime contractor against SSP and MSFC requirements;
- Provides data, analysis, and evaluations in support of reviews.

2.2.3.1.1 System

The MSFC PRACA database is housed on a single Sun computer system (the Host) running the Solaris 2.6 operating system. Since this operating system is a Unix variant the PRACA database system is known as UnixPRACA or UPRACA. This system runs the Oracle 7 relational database application to maintain and manage the PRACA data.

This Host system is connected to a NASA MSFC firewall-protected LAN. A web server is used to provide client access to the UPRACA data system. The client machines access the UPRACA database by running a commercial browser on the client system. The data can be queried and reports generated from either the Host or the authorized client computers. Database management is performed on the Host computer directly.

2.2.3.1.2 Network

MSFC's PAS is implemented on the MSFC internal LAN, which is protected by firewall security. There is a unique User ID and passwords pair required to access the system. The webserver's authentication of the user is used to manage access control. To gain access to the UPRACA data, a user must fill out a "PRACA System Access Request" form at the online website at http://upraca.msfc.nasa.gov:8018/praca/review/public/html/index.htm. The PRACA System Administrator will approve the request and email a unique User ID and password to the user. Database management is performed on the host Sun computer directly.

2.2.3.1.3 Database

The MSFC Problem Assessment Systems UPRACA is based upon the Oracle 7 database. It has approximately 18,000 problem reports and in excess of 900,000 records. This sixteen table database is approximately 230 megabytes in size with the whole UPRACA database able to hold up to 5 gigabytes of data. All tables share the common field "MSFC_REPORT_#".

2.2.3.2 Data Collection

The MSFC PAC obtains the PRACA-reportable information from the four MSFC prime contractors' electronic data systems. These prime contractors each cover a separate component of the launch system. The components are Space Shuttle Main Engine (SSME), External Tank (ET), the Reusable Solid Rocket Motor (RSRM), and the Solid Rocket Booster (SRB). The transfer of PRACA-reportable information from the contractors is achieved in one of several ways: email, fax or electronic transfer.

The SSME PRACA data comes from Boeing North America/Rocketdyne Division in Canoga Park, California. An automated PRACA data file generation and electronic submission to MSFC occurs at night when appropriate. Rocktedyne's system is the Problem Reporting and Management System on an IBM 390 running an IMS database.

The ET data comes from USA (formerly Lockheed Martin) located at Michoud, Louisiana. A manual process starts the PRACA data file generation and electronic submission to MSFC PAS as required. MSFC manually invokes data load upon notification of file transfer. The USA Corrective Action Process System (CAPS) PRACA report document is also faxed to MSFC for inclusion into the hardcopy file kept for each report. The NSTS 08126 required fields are added to the CAPS data and in the transfer file format.

The RSRM data comes from Thiokol located in Brigham City, Utah. They deliver a PAS-item PRACA document to MSFC via fax and e-mail of Microsoft Word documents. Not all of Thiokol's discrepancy reports are elevated to a PRACA-reportable item and very few NSTS 08126 data fields are included.

The SRB data comes from USA (formerly USBI) at KSC. USA delivers PAS-item PRACA documents to MSFC via fax and e-mail of Microsoft Word documents. Not all documents in the USA Nonconformance Information System are elevated to a PRACA-reportable item and very few NSTS 08126 data fields are included.

The data collection process flow always has the MSFC PAC loading electronically or keying a PRACA problem report into MSFC PRACA data system, with standard NSTS 08126 Revision G codes and formats added. The full MSFC process flow is shown in the figure 4 below.

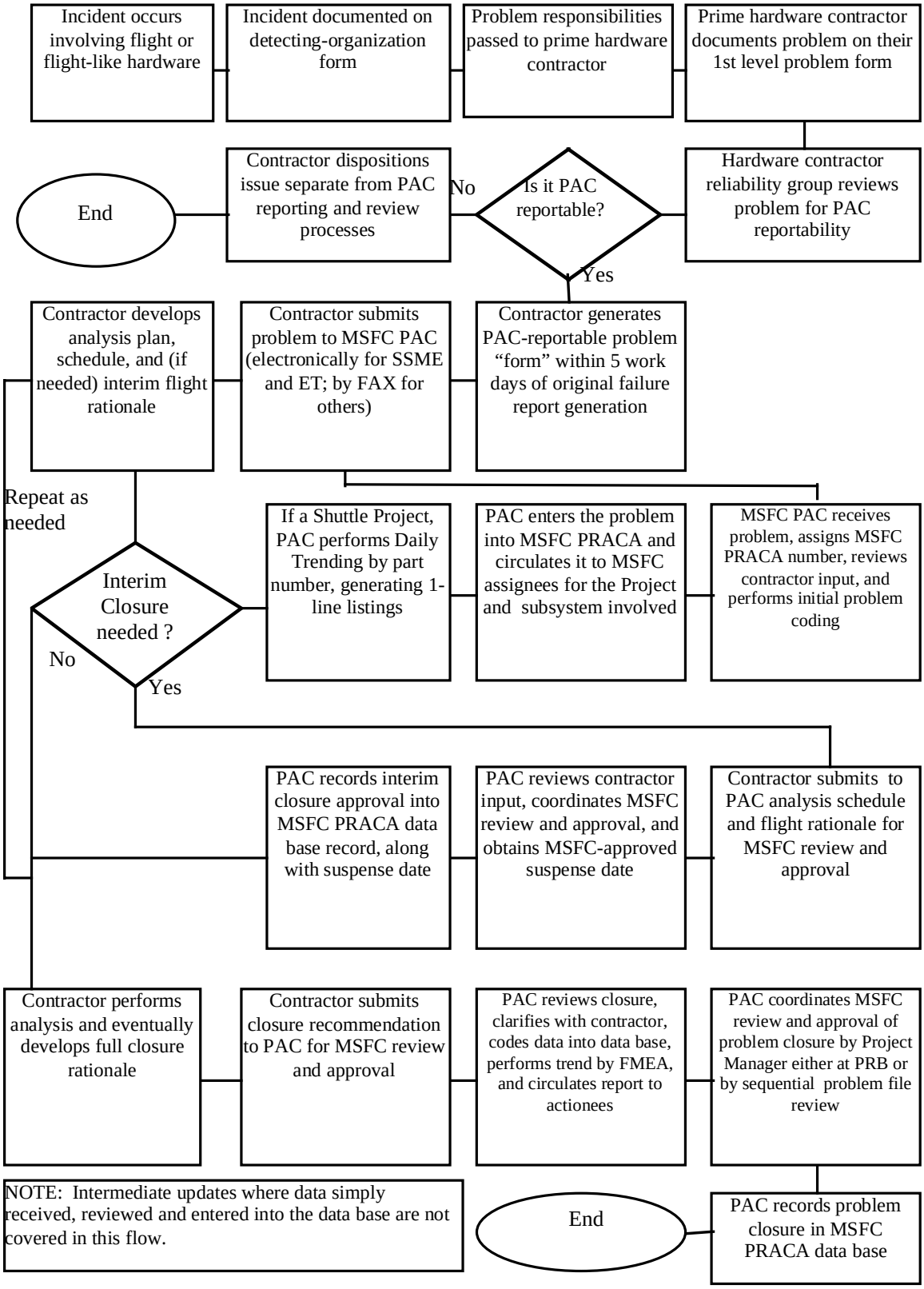

Figure 4 - MSFC PRACA Data Collection Process Flow

2.2.3.3 Interface

The MSFC PAS provides an interface to the UPRACA system and PRACA data via a web-based access using any of the commercial browsers as the client front-end. The user interface was developed for the S&MA office and expert users. It is not developed as a general purpose or managerial support interface to PRACA data. The web-based online application is written in C that generates the HTML used for screen displays. Embedded SQL is used in the C program for the database calls.

2.2.4 KSC Ground Operations PRACA System

The KSC Ground Operations Support is operated by the United Space Alliance (USA) under the SFOC (Space Flight Operation Contract) to the SSP. The SSP PRACA requirements are documented in QA-001 and QA-002 [ref 22 and 23]. These documents define methods and responsibilities for documenting, dispositioning, and obtaining corrective action for problems encountered regarding hardware and software for which the KSC Space Flight Operation Contract (SFOC) operated by USA has responsibility. As with all PRACA systems, overall requirements for establishing a closed loop problem-reporting system are documented in NHB 5300.4(1D2) Safety, Reliability, Maintainability and Quality Assurance Provisions for the Space Shuttle Program. The Level II requirements for implementing this system are defined in NSTS 08126 Revision G.

Key Information about the KSC PRACA System is presented in the table below:

System Name:	Shuttle Processing Data Management System (SPDMS) PRACA
Point of Contact:	NASA: Ruth Harrison, Randy Segert Contract: Daniel Mondshein, USA
Location:	Primary system: KSC Support Sites: JSC and Palmdale via web interface only
Operational Since:	The PRACA data available dates from January of 1978
Purpose:	The KSC SPDMS PRACA database is the repository for KSC ground operations PRACA data
Platform:	IBM 9000 with a Compaq computer running Window as console
O/S:	VM
Database:	SQL/DS
Application Programs:	Client App: Command line interface to database via terminal application Database Management: via command line and SQL DS tools Reporting: via command line or ADAM web-based query interface
Security Model:	Primary: Network connectivity to the SPDMS system Passwords/UID: Required for the SPDMS command line client and the ADAM web-based query screen

Requirements Document:	NHB 5300.4 (1D-2), NSTS 08126, QA-001, QA-002, QA-019
Web Info:	http://usa1.unitedspacealliance.com/hq/warehouse/ssp%5Ftechnical/ksc%5Fpr.htm http://usago1.ksc.nasa.gov/apps/usago/orgs/sre001/ and http://www.usano.ksc.nasa.gov/APPS/usano/orgs/61-2x/supportability/index.cfm
Other:	Manages MRs, PR/DR/IPRs. Used for engineering disposition and workflow management.

Table 4 - KSC PRACA System Information

2.2.4.1 Architecture

The KSC Ground Operations Shuttle Processing Data Management System (SPDMS) houses another component of the SSP's Problem PRACA System. The KSC SPDMS PRACA database is the repository for PRACA data. The database also contains Shuttle Payloads IPR's initiated during integrated operations. The current data set contains the non-archived data presently residing on the SPDMS computer from approximately 1-Jan-1978 through the last 24 hours.

2.2.4.1.1 System

The KSC PRACA is part of the SPDMS system and is managed by USA Ground Operations. The SPDMS database is housed on a single IBM 9000 computer system (the Host) running the VM operating system. This system is controlled through a console application on a Compaq PC compatible computer running the Windows NT operating system. The database is implemented in SQL/DS that supports multiple databases for much of the ground operations activities.

This Windows NT system is connected to the NASA KSC LAN and allows connections via terminals and remote connections. The terminals access the database by running a command-line interface to generate reports. The data can be queried and reports generated from either the terminals or the authorized remote connections using the command-line interface. Database management is performed on the LAN-connected terminals.

2.2.4.1.2 Network

KSC PRACA on SPDMS is implemented on the KSC internal LAN, which is protected by a firewall. The IBM VM mainframe does not natively support IP (internet protocol) connections and is otherwise accessed via a Compaq computer running mainframe

connectivity software. There are passwords and User ID required to access this front end Host. Database management is performed on the Host computer directly.

2.2.4.1.3 Database

A relational database SQL/DS is used on the SPDMS to manage the PRACA data at KSC. The SPDMS holds at least nine separate databases for various group operations functions. There are 35 primary and support tables. Common fields are "Reference_Report_Number" and "USER_ID".

2.2.4.2 Data Collection

The data collection process flow is described in the chart below.

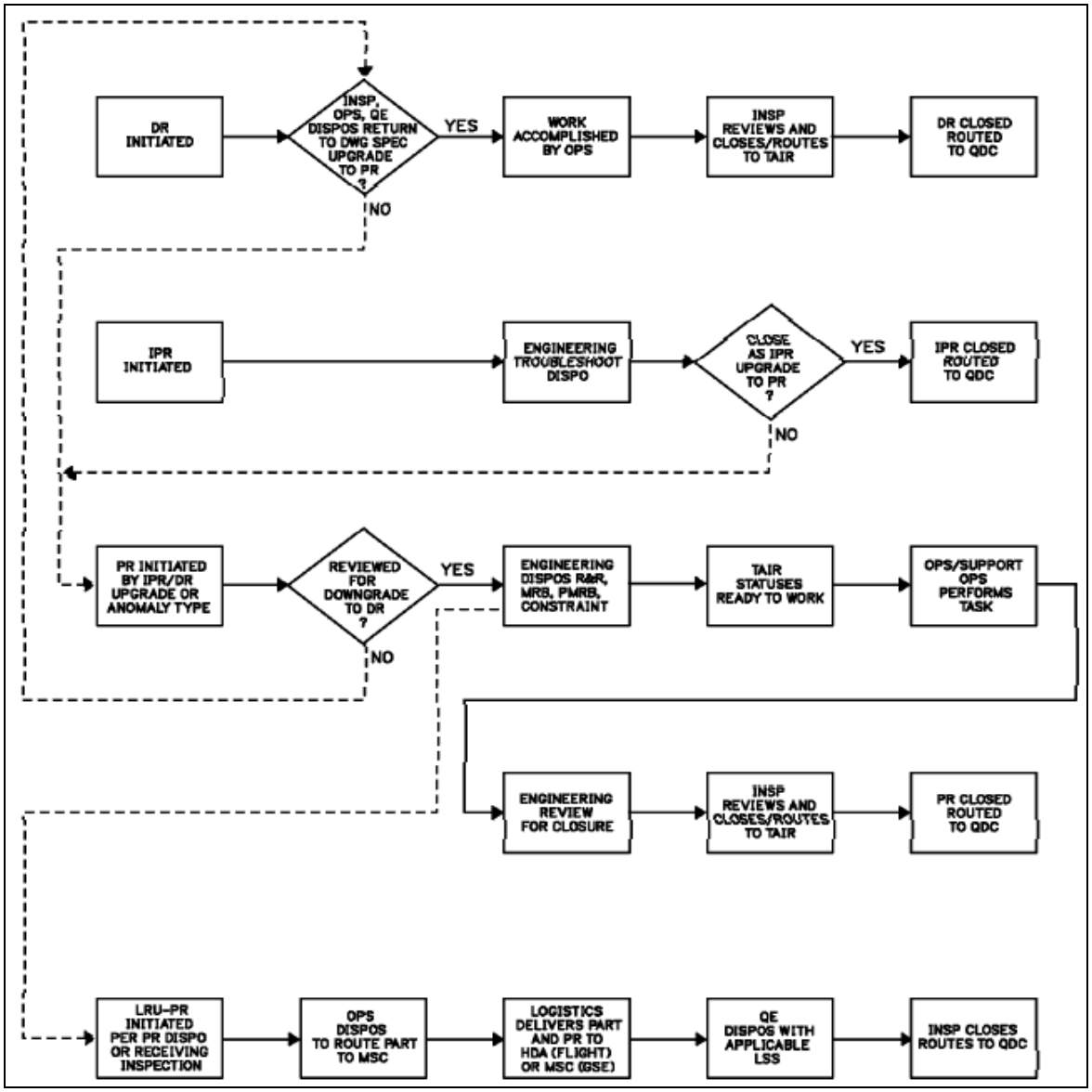

Figure 5 - KSC Nonconformance/Problem Report Flow

2.2.4.3 Interface

Access by analysts and the KSC PRACA team is via a command-line interface to the mainframe. There is a variant of the ADAM (see section 2.2.5) custom user interface to access a copy of the SPDMS mainframe system PRACA data.

The SR&QA groups at NASA KSC have done reporting and trending in the past with varying degrees of user community acknowledgement and support. Reports can be found at http://usago1.ksc.nasa.gov/apps/usago/orgs/sre001/ and http://www.usano.ksc.nasa.gov/APPS/usano/orgs/61-2x/supportability/index.cfm. The reports are generated by a group of data experts in consultation with the inspectors and engineers associated with the data acquisition and problem identifications.

2.2.5 ADAM Data Warehouse

The Program Compliance Assurance and Status System (PCASS) is defined by the System Integrity Assurance Program, NSTS 07700 Volume XI. It is currently in transition from a mainframe to distributed web-based architecture. This mainframe design limits the application of newer technology needed for enhancement of capabilities. The Problem Reporting interface in PCASS is provided by the Integrated Problem Assessment System (IPAS). The IPAS component, and most of the other PCASS systems, are in the process of being replaced with a web-based data warehouse architecture ADAM (Advanced Data Acquisition and Management).

ADAM is a centralized data warehouse system that support PCASS concepts and the proposed WebPCASS project to provide access to data from numerous sources, with the goal to accurately analyze and assess the status of Shuttle pre-flight, flight and post-flight activities. The ADAM platform is built and maintained by the United Space Alliance (USA) under the integrated Space Flight Operations Contract (SFOC) with the target to fulfill the PCASS requirements for an authoritative source for searching and reporting of NSTS 07700 defined data.

ADAM is being developed to apply new technologies (such as web interface and data warehousing) to fulfill expanding user requirements. The ADAM Data Warehouse's stated goal is to: provide the SSP users the ability to access historical reliability performance; allow for the identification of patterns of deficiencies; allow development of statistical data to support continuous improvement of the fleet; and provide engineering data for determination of remedial and/or corrective actions (design improvements). USA desires to achieve this by assembling PRACA and other SSP quality and safety data into the ADAM data warehouse. ADAM is planned to provide the hardware and software infrastructure that enables the integration of multiple operational databases into a single database view designed specifically for reporting and analytical processing (refer to Figure 7). This is not yet implemented in the current instance of ADAM.

Key Information about the ADAM PRACA System is presented in the table below:

System Name:	ADAM (Advanced Data Acquisition and Management)
Point of Contact:	NASA: Randy Segert Contract: Margaret Guardia (USA), Susan Ahrens (USA)
Location:	Primary system: NASA JSC (Houston) Support Sites: NASA KSC (mirror), all SSP sites
Operational Since:	Initially operational as FRED (Fast Retrieval of Enterprise Data) in 1994 sponsored by NASA HQ Code Q. It became ADAM in 1996.
Purpose:	Provide centralized access to SSP PRACA to fulfill NSTS 07700 trending and analysis requirements.
Platform:	Hewlett-Packard V2200, Compaq Proliant

O/S:	HP-UX 11.0.x, Windows NT 4
Database:	Oracle 8.0.5.x
Application Programs:	Client App: HTML interface written in ColdFusion on Windows system Database Management: Via Oracle tools Reporting: Custom Query screens, Crystal Reports, and Hyperion Essbase
Security Model:	Primary: Limited IP access to Web server. Local NT domain access is required for the use of Essbase tools. Passwords/UID: A password and user ID is required to log into the browser front end.
Requirements Document:	NHB 5300.4 (1D-2), NSTS 08126, USA 96-dw0001
Web Info:	http://usa1.unitedspacealliance.com/hq/warehouse/
Other:	ADAM supports many of the other PCASS datasets

Table 5 - SSP ADAM System Information

2.2.5.1 Architecture

ADAM is envisioned to be a central warehouse for all of the SSP PRACA data. Its current implementation is as a data store for a copy of each of the separate PRACA systems data and schemas. The data gets updated from the source systems daily as a complete copy into the ADAM Oracle database. The data warehouse concept is used to support future advanced trending and analysis without disturbing the Project PRACA systems. Since there is no master database schema or integration capability between the copied PRACA databases, the data warehouse is currently only capable of serving as a central data store. This is a critical point as this means that any trending and analyses must be done on each of the separate data sets and then somehow unified.

ADAM is a mirrored system, with the central database running on a HP-UX server and a Compaq Windows NT system running a web server for client access. One set of machines is housed at KSC and another set is duplicated at JSC.

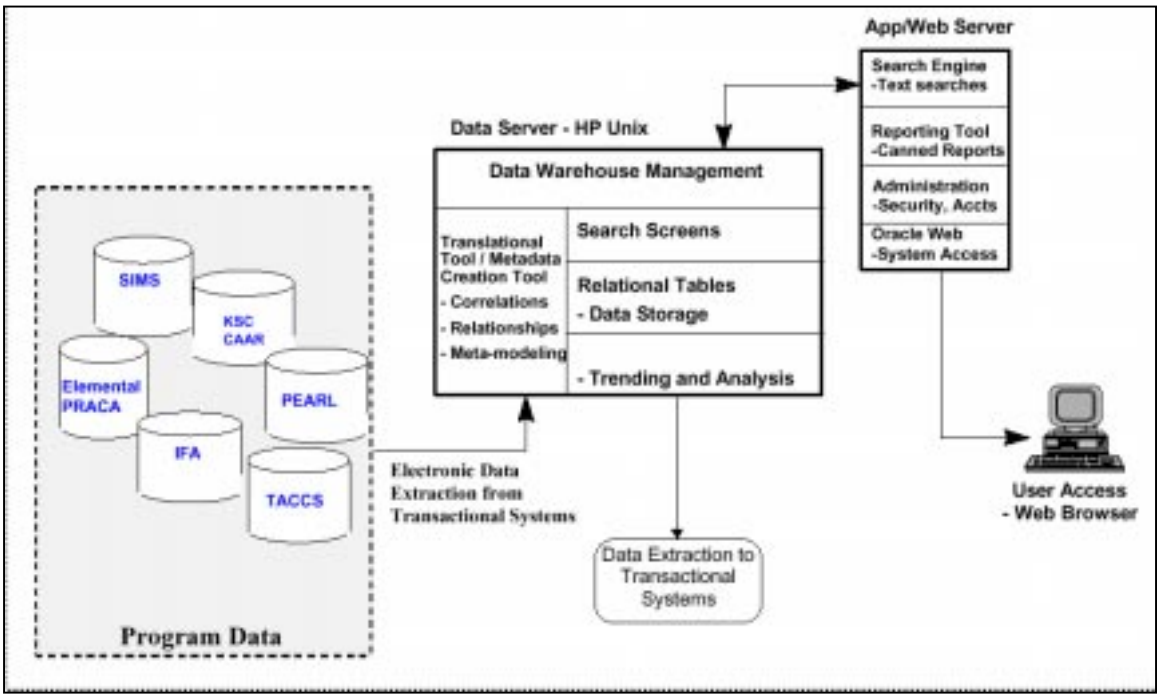

Figure 6 – SSP ADAM System Deployment

ADAM maintains copies of the following SSP PRACA datasets:

- Orbiter CAR (PDSS) - The Orbiter PRACA Data Support System (PDSS) contains data related to Orbiter Contractor-Furnished Equipment, Government-Furnished Equipment and Ground Support Equipment for which United Space Alliance (USA) has design responsibility.
- MSFC PRACA - MSFC PRACA contains nonconforming articles for materials, parts, assemblies, and systems (items) that are received, manufactured, modified or tested at MSFC.
- KSC IPR/DR/PR - The KSC SPDMS II PRACA database is the repository for SFOC (USA), BOC (EG&G), & OMDP (Boeing North American, Palmdale, CA) PRACA data. The database also contains Shuttle Payloads IPR's initiated during integrated operations. The current data set contains the non-archived data presently residing on the SPDMS computer from approximately 1-Jan-1978 thru the last 24 hours.
- KSC CAAR - The KSC SPDMS II CAAR database contains Corrective Action Assistance Request information from various KSC contractors/organizations seeking recurrence control action(s) and subsequent closures. Contractors include: USA (SFOC), Lockheed Martin (SPC), McDonnell Douglas (PGOC), Boeing North American (Orbiter), USBI (SRB), Martin Marietta (ET), EG&G (BOC) and others. The data set contains information from 1984 thru the last 24 hours.
- In-Flight Anomaly - The user can query In-Flight Anomaly data sets using almost any combination of this screen's fields. The one constraint to available combinations of fields used is when "Choose Data Element 1" is not used, "Choose Data Element 2" cannot be used also.

- Government-Furnished Equipment (GFE) PRACA - The GFE PRACA System contains problem data and information related to Government-Furnished Equipment.
- PR Images (SIMS) - The PR Images (Shuttle Image Management System) screen will allow the user to perform an optimized data search across one or multiple data sets. The user can select specific data sets (PR Type) to search, enter search criteria for commonly used data elements (e.g., problem date, problem status, part name, part number, etc.), or select from a pick list or entering in a text specific data elements from the selected data sets. Wildcards can be used to support searches.

2.2.5.1.1 System

The Oracle 8.0 database application is housed on a Hewlett-Packard HP Vclass server running HP-UX 11.0, a Unix variant. A separate Compaq Windows NT system supports the web server that maintains a dynamic HTML interface written in Coldfusion. Hyperion Essbase software and Crystal Reports software also runs on another Compaq for additional database analysis. Both the HP and the Compaq system are mirrored to twin systems, with one set of systems located at KSC and the other at JSC. This is for data redundancy and to support two separate local infrastructures. The database is mastered at the KSC site and maintained and managed at the NLSD USA contract building. Client query access is provided via the custom Coldfusion application available through the web server running on the Compaq systems. Data storage is provided via RAID 5 disk arrays.

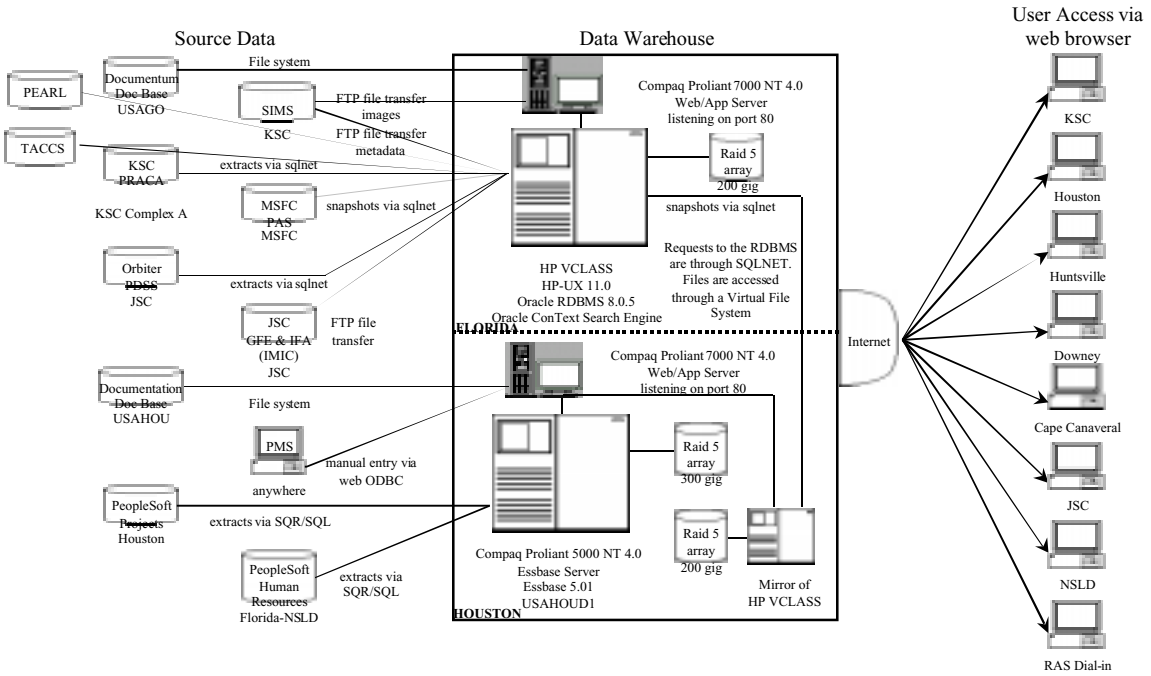

Figure 7 - ADAM Data Warehouse

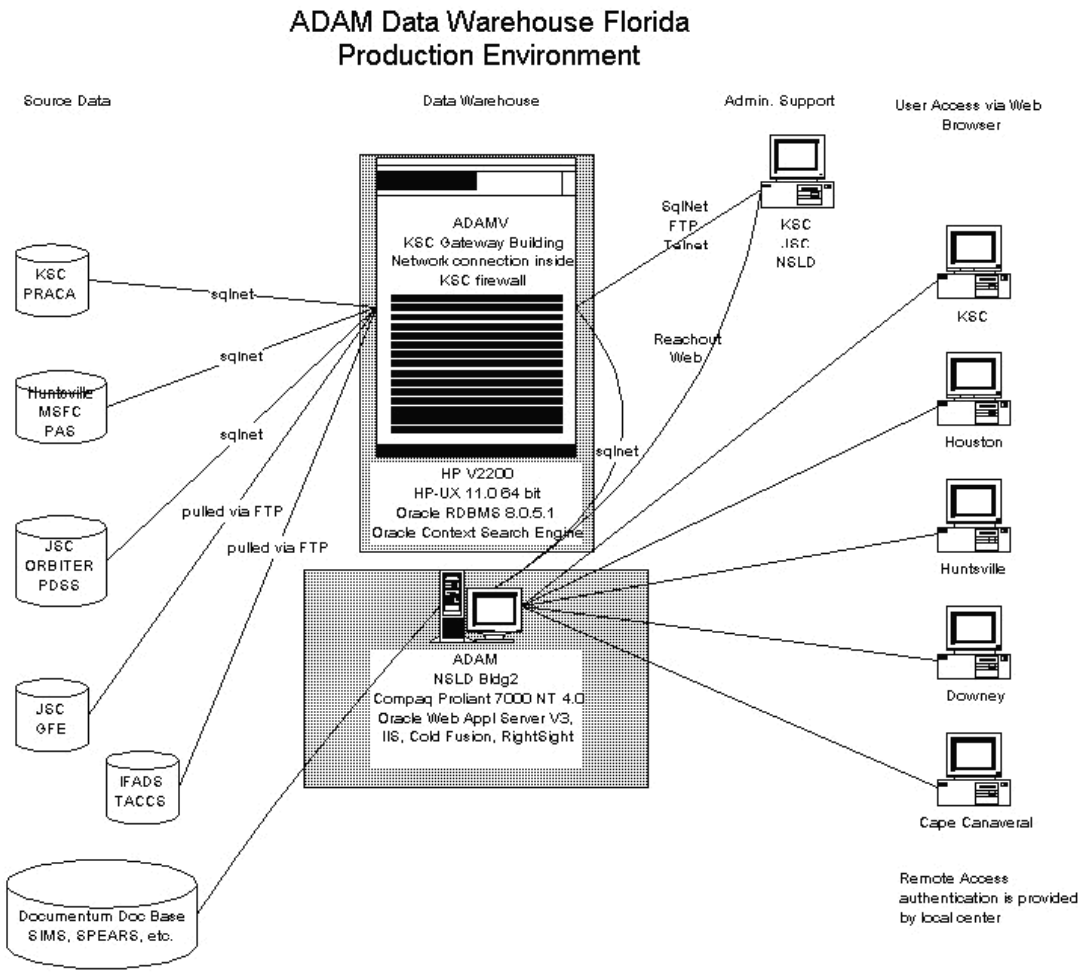

Figure 8 - ADAM System Deployment

2.2.5.1.2 Network

Query access to ADAM datasets is open to Space Shuttle Program personnel who are on trusted domains in the NASA community. These include, but are not limited to JSC, KSC, MSFC, and USA of the other key contractor organizations. Each user is authenticated by logging onto the local Windows NT domain; the domain is then authenticated at the ADAM Web Server using the Microsoft Internet Information Server (IIS) and a ColdFusion front-end application. If the user is not part of a trusted NT domain (such as Mac or Unix systems) or outside the local network, a user ID and a password are required.

A diagram of the network connectivity between the two mirrored portions of ADAM is shown in the figure below:

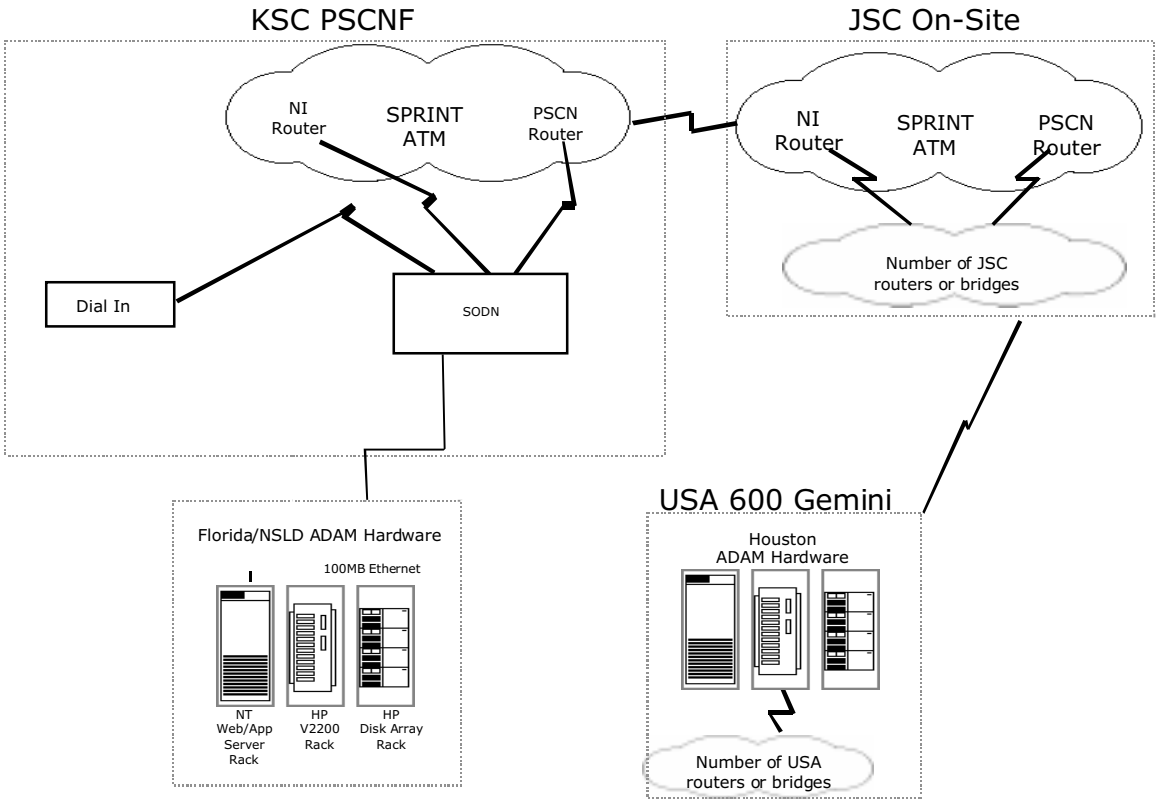

Figure 9 – ADAM Data Warehouse Network Connectivity

2.2.5.1.3 Database

The ADAM database is implemented using Oracle 8.0.x database software on the HP-UX system. There is no overall data warehouse schema or data field naming convention that is consistent across all of the various PRACA system data within ADAM. This means that ADAM is a largely unstructured database.

ADAM does not have a naming standard for entities/attributes within the database. The current database design of ADAM is to keep the table and column names in the warehouse the same as the source PRACA systems'. The advantage of doing this is to minimize the confusion to database users familiar with their transactional systems. Thus, a column called 'colA' in table 'tabA' would map directly from the source system to the ADAM data warehouse. With the advent of a web-based interface, column name became less important than the definition of that column's value. It was also originally thought that users would feel more comfortable with the validity of the warehouse data and also make the ADAM data audit procedures clearer. However, these assumptions have not been validated through this Study.

2.2.5.2 Data Collection

The SSP PRACA data is generated and maintained in individual Element/Project databases. On a nightly basis, the new and modified data is extracted from each of these systems. A full extract may be done if requested. The data transfer program between the source PRACA systems and ADAM is initiated by UNIX shell scripts that are executed by a UNIX cron job. The data extract files are electronically transferred to the ADAM data warehouse where a loader program is initiated. These programs are a collection of UNIX shell scripts and PL/SQL packages and procedures stored in the ADAM Oracle database.

The loader program reads the extracted file and parses the data into mapped database table fields. If extensive formatting errors or data errors are detected during the load process, the load is terminated and no data updates are committed. Formatting errors that are easily corrected are performed and the loader process restarted. Daily reports for the loads are generated and distributed via e-mail. If a load was unsuccessful, the data load coordinator works with the Project contact until the load is successful, at which time a follow-up e-mail is generated and distributed.

For example, to capture the KSC SPDMS PRACA data, the job is run nightly at 12:10 a.m. and is explained below:

a. A UNIX shell script starts the transfer process. The shell script invokes an SQLPLUS session that in turn executes the Oracle-stored procedures involved in the transfer process.
b. The stored procedures are stored in the Oracle database residing on ADAM. The procedures query the source database for data inserted, modified, or deleted on the previous day and subsequently modify the warehouse as appropriate.

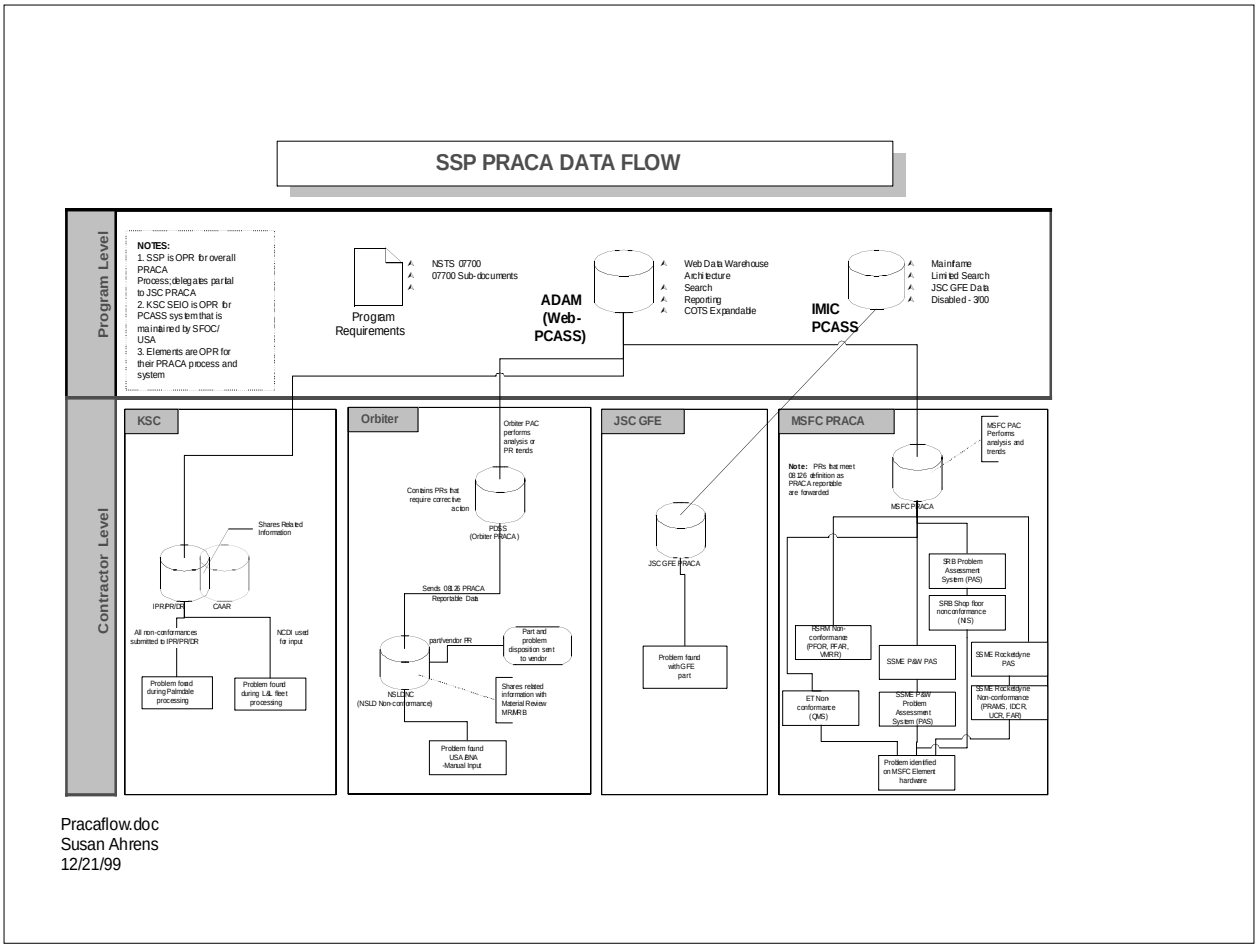

Figure 10 – SSP ADAM Data Collection Process Flow [S. Ahrens]

2.2.5.3 Interface

The interface provided to ADAM clients is through commercially available web browsers available for all major computer platforms. The web server application is written in ColdFusion as a series of presentation and query HTML-based web pages. The interface was developed to provide basic query capability for each of the PRACA datasets.

The "Search All PRACAs" data screen will allow the user to perform an optimized data search across one or multiple data sets. The user can select specific data sets (PR Type) to search, enter search criteria for commonly used data elements (e.g., problem date, problem status, part name, part number, etc.), or select from a pick list or entering in a text specific data elements from the selected data sets. Wildcards can be used to support searches.

3.0 PRACA System Findings

Upon completion of the on-site interviews, reviews and technical assessments of the multiple PRACA systems, the team identified a set of general findings, and a set of findings specific to the four technology areas identified in our Approach. The overall assessment of the existing PRACA systems is that they are inefficient and potentially vulnerable to data loss and input error. The current approaches do not scale or adapt easily to changes. The expert knowledge that is required to utilize the PRACA systems is not captured or documented. Overall, the existing PRACA system is incapable of supporting Program-level risk assessment. These general and specific technical findings are discussed in the following sub-sections.

3.1.1 General Observations of the SSP PRACA Systems

3.1.2 Quality PRACA Workforce

The PRACA system workforce is highly skilled and motivated. The PRACA system managers exhibit a clear understanding of the important role PRACA data plays in SSP safety and have an excellent grasp of the scope and breadth of their system and teams' domain expertise and domain responsibilities.

During site visits, we typically met with teams of 5-8 people for interviews. From the discussions, it was clear that the staff each knew their individual responsibilities as well as each other's skills and team responsibilities. The PRACA system workforce and managers freely expressed visions, goals, and plans for system improvements and upgrades. It is clear that they creatively could and should contribute solutions for a unified SSP PRACA system.

3.1.3 Current PRACA Does Not Meet SSP Needs

The PRACA systems in use by the SSP are not sufficient to meet the SSP current and future needs (as expressed by NASA SSP management, the SSP requirements documentation (i.e., NSTS 07700 Volume XI), and from a sustainable workforce perspective). This general finding is primarily due to lack of clarity in expression of a vision for PRACA, which is the result of three primary causes.

1. The SSP is currently able to accomplish its PRACA Shuttle management tasks, yielding the perception that "PRACA works." Because of this perception, questions addressing the essential functional, systematic and architectural aspects of PRACA are not being asked.
2. The SSP requirements documentation does not preclude the use of data outside the formal PRACA data systems. This enables a capability much greater than would be possible if the users were restricted to PRACA system data only. As a

result, the SSP has not been confronted with the data limitations of the current PRACA systems.

3. The current SSP PRACA system is perceived as having a system-wide, user-navigable data warehouse capability. This perception is further reinforced by the use of domain experts who "extract" data and reports from the various Project/Element-designed and supported systems. This gives the impression of a system-wide data mining and navigation capability. Because of this perception, the SSP is not articulating and advocating a data warehouse re-architecture to PRACA (believing it already has one).

These three reasons are described further in the following sub-sections:

3.1.3.1 The Perception That "PRACA Works."

The premise of the PRACA capabilities described in NSTS 07700 Volume XI sections 3.4 and 4.1.5.x is to "integrate program element trend systems, perform analysis, and provide data formatted for management visibility" to support Shuttle Safety Assessments. The SSP does this by reliance upon subsystem domain experts, and the performing SRQ&MA organizations skilled personnel, to report status and trends to the Program office. The domain experts possess substantial institutional knowledge and are able to draw from information outside the PRACA data systems. The reports provided to the SSP therefore are based on large amounts of data outside of the PRACA systems. The loss of the domain experts and the external data sources would significantly degrade the quality of the PRACA reporting and trending. The use of domain experts enhances the quality of the knowledge extracted from the PRACA systems, giving the Program Office the mistaken impression that the PRACA systems alone possess equivalent data and knowledge-generation capability as that presented in the reports.

For the trending and analysis groups to perform their tasks using current PRACA, it is sometimes necessary to filter or correct the data and generally augment PRACA data to produce meaningful results. Several NASA SR&QA groups identified this practice as necessary to perform meaningful trending and analysis for the Program office. The JSC Shuttle Orbiter (Code NC) SR&QA group, for example, created and manages the Shuttle Risk and Reliability Analysis Database (SRRAD) and created manual and automated filtering and data processing routines for this purpose. The SRRAD database and data filtering and correction process are examples of data and expertise upon which the SSP reports are dependent but are not part of the formal PRACA system.

3.1.3.2 The Use of Non-PRACA Data in Reports

The use of data outside the formal PRACA system has allowed the evolution of informal data systems upon which the SSP depends. These informal databases exist, in many cases, at the expense of a proper upgrade of the formal PRACA systems.

The base SSP PRACA requirements documentation (NSTS 07700) imply that a "PRACA System" will be the official repository for all data necessary to manage Shuttle problem reporting and corrective action assessment, diagnosis, and trending. However, the NSTS 08126 Revision G requirements also turn responsibility for generating the status, assessment and diagnosis over to Project/Element domain experts with no constraints on the data they are permitted to use to generate the reports. In order to produce the best reports possible, the experts naturally draw from all the information they can access.

The dependence of the SSP on domain experts to produce reports is codified in the requirements document (i.e., it is the responsibility of the domain expert centers to manage their subsystems and report their data to the program office). This has effectively hidden the lack of stand-alone capability the SSP desires for PRACA. It has also hidden the fact that the PRACA system cannot be data mined by the non-expert users. The expert users can manually navigate the various information systems using implicit and innate familiarity with the data, thus giving the appearance of a data mining capability. A neophyte (or non-expert user) would not have the knowledge or context to understand the syntax, or codes used for each of the PRACA systems. Indeed, an expert on one SSP PRACA system is <u>not</u> an expert on all PRACA systems.

As with any large requirements-based information system, the domain experts have found that it is easier to build and manage an informal database to augment PRACA data "outside" of the SSP PRACA purview than it is to upgrade the SSP PRACA databases. For example, as mentioned in the section above, the JSC SR&QA group performs trending and analysis for the Program office by creating and managing the SRRAD database. The SSRAD database is used in conjunction with the PRACA data but is not part of any formally recognized PRACA system. These adjunct PRACA data sources and their requirements need to be addressed in the overall SSP PRACA picture.

3.1.3.3 The Perception that PRACA is a Navigable Warehouse of Data

The SSP has expressed wishes to incorporate the individual PRACA systems into a unified program data warehouse but has not initiated a major re-architecture or training program to elevate the focus from the SSP Element/Project level to the Program level. The Project-level or component PRACA systems resident at JSC, KSC, and MSFC have been designed and implemented by the PRACA domain experts at each center. These systems were developed to meet their individual task and project support needs as stand-alone systems. The inevitable local prioritization of tasks results in no two systems having the same global motivation for existence or the same technical implementation basis. The Project-level systems are not innately amenable to a hybrid data warehouse architecture.

USA's ADAM is a good first attempt to provide unified PRACA data and some associated information. The ADAM effort sidesteps the individual Project PRACA system differences by duplicating the data onto one site, where an interface and mapping can insulate the user from the navigation difficulties. ADAM cannot, however, resolve

the issues of data quality, consistency, integrity, and breadth, which are limited by the source PRACA systems. ADAM is increasing data visibility and bringing attention to data errors and data field mapping inconsistencies across the PRACA systems. ADAM is not addressing the system-wide architectural changes required of the Project systems.

Much of the data the Program requires and desires from the PRACA systems to make them more useful for Safety and Risk analysis are not consistent with the current Project/Element focus. Data currently gathered for the Program that is not necessary for local domain needs is generally handled with less care because its value and use are locally subjective. This is important to note for a number of reasons. It can lead to incorrect entries because the person making the entry does not understand the purpose of that data field in the PRACA form. Additionally, end users such as people doing trending and analysis may not understand the context in which the data were acquired and therefore why fields are being filled out in particular ways at operational sites. These mutual misunderstandings can produce incorrect data, which degrades the validity of any trending analyses using these data fields. The main commonality between the PRACA systems comes from the NSTS 08126 document. While each of the various PRACA systems comply with the current 08126 revisions, the Project-level PRACA systems have there own guiding requirements and documentation, of which the 08126 requirements play only a partial role. Data field naming conventions are solely left to the Project to implement in their local databases.

Streamlining efforts (efficiency, turn-around time, work-flow) at the Project and domain level tend to resist addition of fields that impede the streamlining efforts. This is due in part because the local PRACA system is often used for a number of functions besides problem reporting and corrective action. Thus many individuals collecting the data may not see their job as connected to the SSP system-wide PRACA effort. This also contributes to opacity and misunderstandings of the roles and purpose of the SSP PRACA systems.

3.1.4 No "PRACA System-wide" Philosophy

There is a lack of a clearly expressed vision for SSP PRACA and subsequent lack of a system-wide buy-in to the "PRACA System" philosophy. While the Space Shuttle Program expectation for PRACA is as a part of the PCASS, many view the PCASS as one of the several systems comprising PRACA data sources rather than as a PRACA end design goal. The problem is further complicated by a lack of clearly acknowledged "PRACA owner" For example, none could be identified or established during a visit to the SSP office in January 2000. *(Note: Since January a PRACA owner has been identified, within the SSP as well as for the USA contract, by the JSC PET activity).*

The creators or Project-level managers of the PRACA systems accept the SSP system-wide data resource goal but do not yet view PRACA data as a Program-wide resource that can be controlled and managed by the SSP office. An overall "PRACA System" as an organizational or technological entity does not exist, and was not required by the

NSTS 08126 Revision G document. The JSC PET has rewritten and enhanced the NSTS 08126 document to a Revision H and this is discussed in section 3.1.4.

3.1.4.1 Effect on PRACA Data

The data collection workforce is not currently trained in PRACA system Program data needs and usage. The data collection complexity imposed on the local (domain) PRACA teams is not a primary consideration addressed in the PRACA requirements documentation. Because of the Project-focused development of the individual PRACA systems and their work practices, the resulting multiple definitions, levels and functions of PRACA lead to opacity between parts. That is, each user of a PRACA system understands it from the viewpoint of their Project/Element and their task. There is not a training process enabling a universally shared understanding about what PRACA data is, what its levels are, who has responsibility for which parts of PRACA data, and how to weigh the priorities of Program data collection against local task schedules and deadlines.

We found that Project users, the engineers and technicians who originate reports, were more likely to understand PRACA data from the perspective of their center, or even of their specific job and its procedures, without understanding the larger implications for how the system(s) works and the SSP-wide service that it provides. This can lead to tensions between the functions, and to the possibility of bad data being entered into the system.

For example, technicians at KSC who have found a nonconformance are required to fill out a PRACA Problem Report, Interim Problem Report or Discrepancy Report as a part of the process for dealing with nonconformances. However, the report's central use for them is to schedule the work of repair and assignment of safety constraints on other work, which may not be performed until the nonconformance is dispositioned. Many of the required data fields in the problem report form that are relevant for problem reporting are irrelevant to the scheduling process, and may be seen by users as demanding information to which they do not have ready access or which requires too much valuable time to answer.

One example of such a field is "Vendor". It may be useful for developing trending data at the Program level, but this use is not clear to technicians. The field is not necessary for any of the work that the technicians do, nor is it particularly valuable to the engineers and schedulers who direct the technicians' work. This confusion can lead to technicians filling in any value that they know will pass the inspection process, rather than attempting accuracy.

3.1.4.2 Effect on Future Potential for PRACA

The lack of a clearly articulated and adopted vision across the PRACA systems has an effect on the future potential for safety and risk analyses. Many of the visions expressed by NASA senior management for the ideal "PRACA System" include a prognostic capability with data search, navigation, and mining that extends across the Shuttle

Program. Without some effort to promote unity amongst the systems or their data, the potential technical leverage from similar systems (e.g., the Aviation Safety Program) and NASA research Programs such as Design for Safety will be reduced. There are many opportunities for interaction and data sharing with the digitized Shuttle components databases, commercial aviation maintenance planning and scheduling systems, and model-based reasoning systems that could significantly enhance the utility of the PRACA data for safety and risk analyses within the SSP. This is discussed further in the recommendation section of this report.

3.1.5 NSTS 08126 Revision H Updates

The JSC PET has completed much of a rewrite and update to the NSTS 08126 document. This revision is appended as Revision H to identify it as the successor to Revision G. Revision H better reflects the desired scope and global functions expected of the SSP's PRACA system. The Space Shuttle Program Review Control Board is expected to approve 08126 Revision H in the summer of 2000.

Revision H now states that the goal of the PRACA system is to establish a process to continuously improve the safety and reliability of Space Shuttle hardware, software, and critical ground systems. The PRACA system will provide the SSP and all SSP Elements/Projects:

1) Accurate and immediate visibility into problems; and
2) An accurate historical database to support problem trend analysis, provide failure history, support anomaly investigation, and to document corrective actions.

Revision H also recognizes that PRACA is only useful if the reported information is accurate and correct. It emphasizes that sufficient attention must be paid to insuring accuracy of the data comprising the problem report, failure summary, root cause analysis, and in/out-of-family screening.

NSTS 08126 Revision H defines and enhances the SSP requirements for problem reporting, analysis, disposition, resolution, and trending. Problems that are documented in PRACA include: Space Shuttle hardware (Orbiter, GFE, Flight Crew Equipment, SSME, ET, SRB, RSRM, and cargo integration hardware), Orbiter software discrepancies, SSME software discrepancies, Launch Processing System (LPS), Ground Support Equipment (GSE) and Launch & Landing (L&L) facilities that support mission to mission processing of flight hardware. The Revision H document establishes:

1) Uniform criteria for reporting problems;
2) Requirements for problem disposition and closure;
3) Requirements for documentation of corrective action;
4) Requirements for problem documentation to support engineering and trend analysis;
5) Requirements to support logistics management; and
6) Definition of problem report data elements and terminology.

The NSTS 08126 Revision H now addresses the requirements for extracting the data necessary for trend analysis and reporting. In addition, this latest version of the PRACA system requirements greatly improves and clarifies the requirements for the PRACA systems. Work is continuing on the PRACA data element definitions and establishing the database code translation tables to enable some mapping between the various PRACA systems' data. These definitions and tables are to be included in the final version of NSTS 08126 Revision H.

3.2 PRACA Assessment Area Observations

3.2.1 User-Interface Findings

The team interviewed the various users and evaluated the PRACA systems interfaces where possible. In the case of the JSC government-funded equipment system and the KSC group support system the team did not achieve hands-on access, due to the teams remote location, exclusion from the firewall-protected LAN (security model) and the user interface being designed for local access only.

The team made the following observations with regard to the user interface:

- There is no SSP user interface design specification document.
  - There is no reference user description (i.e., who is the interface designed for, what skill level, what resources are at the users disposal, etc.)
  - There is no reference task list (i.e., what functions does the user need to perform, what data does the user need to access, what ways does the user need to see the information formatted, etc.)
  - There is no reference host/client platform or Operating System target for the interfaces.
- Each of the PRACA systems has a unique user interface. These interfaces demonstrate varying degrees of complexity and capability ranging from command line SQL to Web based interactive reporting.
  - Most of the interfaces are implemented in custom software.
  - None of the systems are fully Web enabled, though ADAM and PDSS are moving in that direction.
  - Most systems have Graphical User Interfaces (GUI's); the remainder use command-line mode text interfaces.
- All the User Interfaces provide a data query capability.
- All the User Interfaces provide varying degrees of reporting and trending capability,

A summary of comparison information for the various PRACA systems User Interfaces is presented in the following table:

PRACA System	Data Query GUI(G) or Text(T)	Report/Trend GUI(G) or Text (T)	Client Application	Report/Trend Group Support

PDSS	G	G	Custom Windows App.	Y (JSC Code NC)
GFE	G	G	MS Access run-time	
KSC	T	T	Custom/SQL	Y (USA contract)
MSFC	G	G	Browser	
ADAM	G	G	Browser	

Table 6 - User Interface Comparison

A further comparison of the user interfaces is presented in the following sub-section.

3.2.1.1 JSC's PDSS

The JSC PDSS User Interface (UI) is a Windows-based custom interface with analysis, reporting and trending capability. The interface is very intuitive, with icons to launch applications, pull down lists, select lists, and script generating and editing capabilities. The PDSS UI has a large external user base and the support group incorporates user feedback in ongoing software upgrades.

The following figure shows the PDSS database query window:

Figure 11 - PDSS Query Screen [T. Dinh]

The PDSS UI allows plotting of the data to produce trend analysis. The software for this is called Trendtool and is a custom application provided to users by the PDSS support

group. The following figure shows Trendtool's plotting capability (count vs. data type) and also displays the selection criteria for the advanced user:

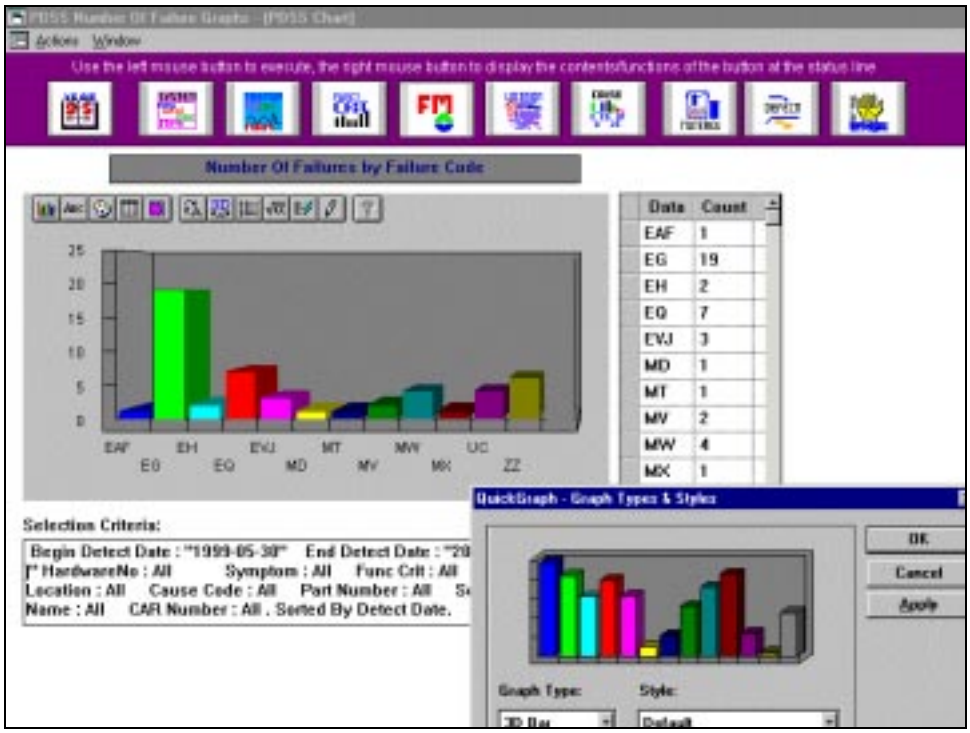

Figure 12 - JSC Orbiter Data Reporting and Trending Interface [T. Dinh]

The PDSS support group has done an excellent job developing this interface and the attention to customer feedback is clearly evident.

3.2.1.2 JSC's GFE

The JSC GFE User Interface is a Windows-based Microsoft Access interface with analysis, reporting and trending capability. The trusted client machines access the GFE database by executing a run-time version of MS Access. The data can be queried and reports generated from either the Host or the authorized client computers. Database management is performed on the Host computer via MS Access directly. The interface is very intuitive with icons to launch applications, pull down lists, and select lists. The GFE UI has an external user base.

The following figure shows the GFE database query window:

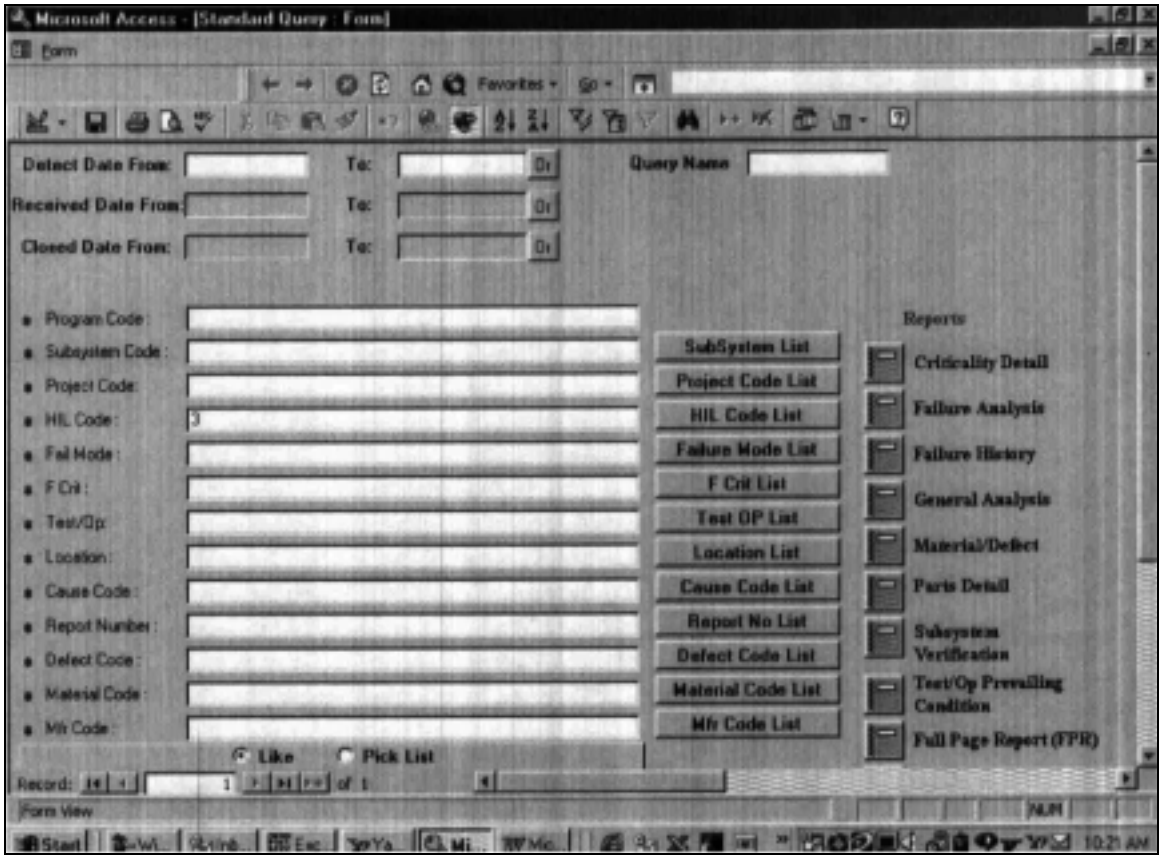

Figure 13 - GFE PRACA Access Database Interface [S. Ferguson]

The MS Access GFE UI allows for report generation and a basic plotting capability is also possible. The following figure shows the GFE UI reporting capability.

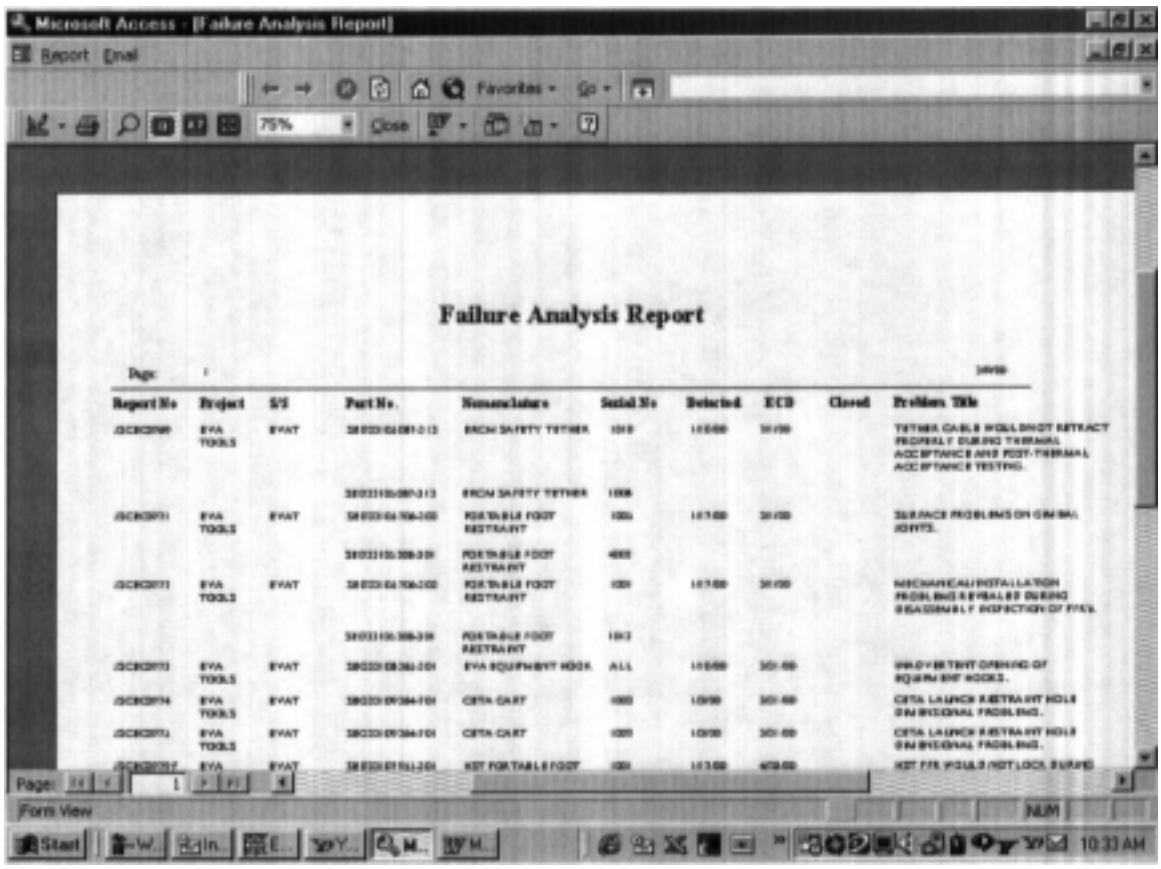

Figure 14 - JSC GFE Data Reporting and Trending Interface [S. Ferguson]

3.2.1.3 KSC's SPDMS

The KSC SPDMS User Interface access is via command-line to the IBM VM mainframe. Users are connected to the mainframe via a terminal session. The figure below shows a sample of the report output from a command line query to the system:

```
DATE: 04/26/00 12:48                PROBLEM REPORTING AND CORRECTIVE ACTION SYSTEM                    PG:  1
                                       REPORT NAME: ADAM SYSTEM INTEGRATION
                                          CONTACT:  SHERRY ERICKSON (1-3001)

PRACA NO: IV4-342269                  WORK AREA : LCC                       STS EFF : 000 -L-CCR
EICN    : CCR-1284                    ORBITR LOC:                           DETECTED: VISUAL INSPECTION
PART NAM:                             ORBITR ZON:                           PAGE NO : 1
PART NUM:                             DATA CODE :                           RPT DATE: 2000-04-25
SERIAL #:                             REPORTD BY: ROZIER          ,1-8707   RSP ORG : USA    -GEN
CRIT SKL:                             CONSTRNT  :                           ENG CHNG:
WEIGHT  :                             MR REQ-D  :                           FRAC CRT:
RETEST  :                             TIME CYCLE:                           HAZ OPCD:

DESC    : FEPCA CARD RECEIVED "TRUE TIME" ERROR ON THE PRIMARY CONSOLIDATED
          GATEWAY.


PRACA NO: IV4-342268                  WORK AREA : LCC                       STS EFF : 000 -L-CCR
EICN    : CCR-1284                    ORBITR LOC:                           DETECTED: VISUAL INSPECTION
PART NAM:                             ORBITR ZON:                           PAGE NO : 1
PART NUM:                             DATA CODE :                           RPT DATE: 2000-04-25
SERIAL #:                             REPORTD BY: ROZIER          ,1-8707   RSP ORG : USA    -GEN
CRIT SKL:                             CONSTRNT  :                           ENG CHNG:
WEIGHT  :                             MR REQ-D  :                           FRAC CRT:
RETEST  :                             TIME CYCLE:                           HAZ OPCD:

DESC    : FEPCA CARD RECEIVED THE FOLLOWING ERROR ON PRIMARY CONSOLIDATED GATEWAY
          - UNIMPLEMENTED OPCODE 1111 - PROGRAM COUNTER 0000008548 - STATUS REGIST
          ER 0000008A - TASK 0000A483 "TRUE TIME"


PRACA NO: IV4-342281                  WORK AREA : LCC                       STS EFF : 000 -L-CCR
EICN    : CCR-1256                    ORBITR LOC:                           DETECTED: VISUAL INSPECTION
PART NAM:                             ORBITR ZON:                           PAGE NO : 1
PART NUM:                             DATA CODE :                           RPT DATE: 2000-04-25
SERIAL #:                             REPORTD BY: ROBERTSON       ,1-0797   RSP ORG : USA    -GEN
CRIT SKL:                             CONSTRNT  :                           ENG CHNG:
WEIGHT  :                             MR REQ-D  :                           FRAC CRT:
RETEST  :                             TIME CYCLE:                           HAZ OPCD:

DESC    : STS101 SCRIPT FILE HAS THE WRONG PAD IDENTIFIER --HAS PAD B SHOULD BE
          PAD A.
```

Figure 15 - SPDMS Command Line Query Output

There is also a variant of the ADAM custom user interface to access a copy of the SPDMS mainframe system PRACA data that resides within the ADAM data warehouse. The ADAM interface to the SPDMS data is shown in the figure below:

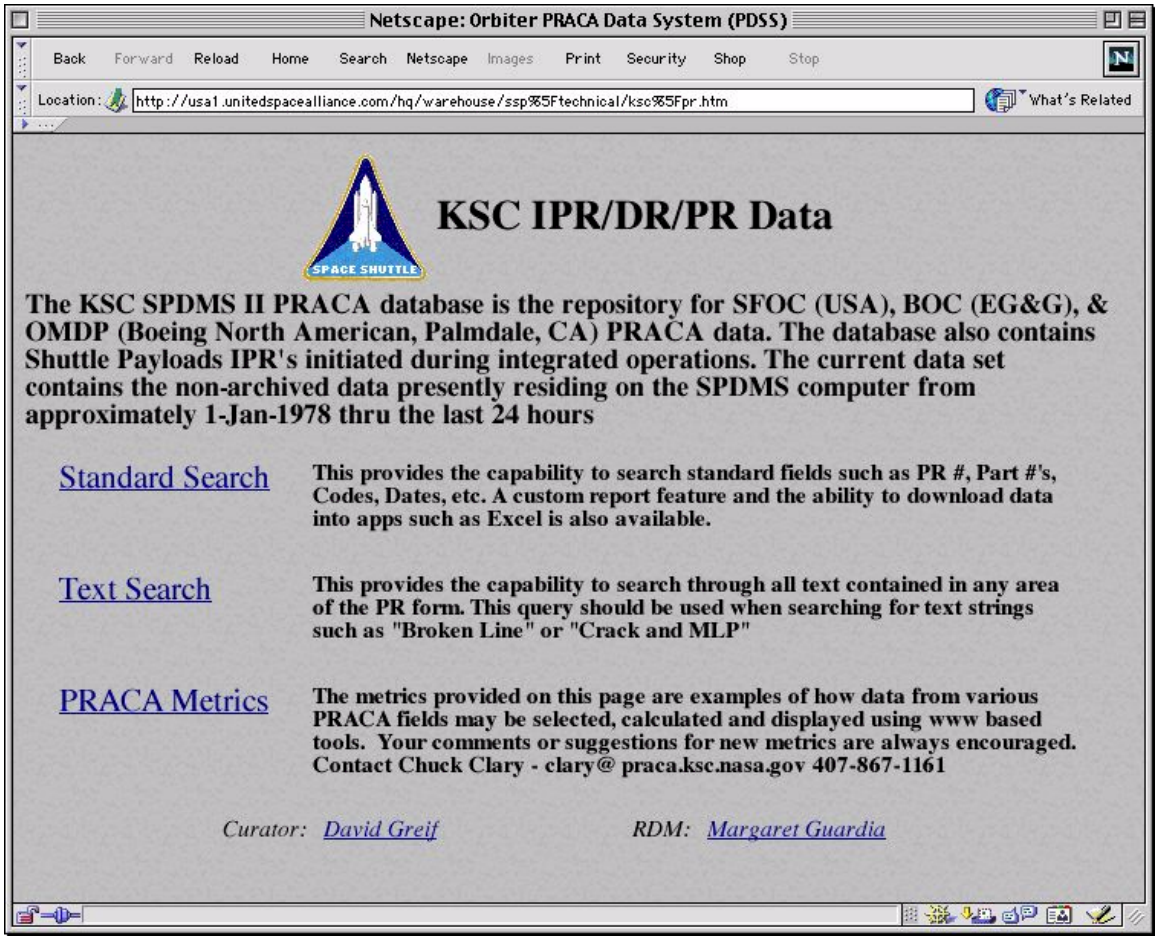

Figure 16 – ADAM Variant SPDMS User Interface

3.2.1.4 MSFC's PAS/UPRACA

The MSFC PAS provides an interface to the UPRACA system and PRACA data via a web-based access using any of the commercial browsers as the client front-end. The user interface was developed for the S&MA office and expert users. It is not developed as a general purpose or managerial support interface to PRACA data. The web-based online application is written in C that generates the HTML used for screen displays. Embedded SQL is used in the C program for the database calls. The interface is intuitive with pull down lists, and select lists. The MSFC UI has an external user base.

The following figure shows the MSFC database query window:

Figure 17 - UPRACA User interface

Basic reporting is also available via select lists in the interface shown above.

3.2.1.5 USA's ADAM (IPAS/WebPCASS)

The user interface provided to ADAM clients is through commercially available web browsers available for all major computing platforms. The web server application is written in ColdFusion as a series of presentation and query HTML based web pages. The interface was developed to provide basic query capability for each of the PRACA datasets.

The "Search All PRACAs" data screen will allow the user to perform an optimized data search across one or multiple data sets. The user can select specific data sets (PR Type) to search, enter search criteria for commonly used data elements (e.g., problem date, problem status, part name, part number, etc.), or select from a pick list or entering in a text specific data elements from the selected data sets. Wildcards can be used to support searches.

The following figures show the ADAM interface and the database query window:

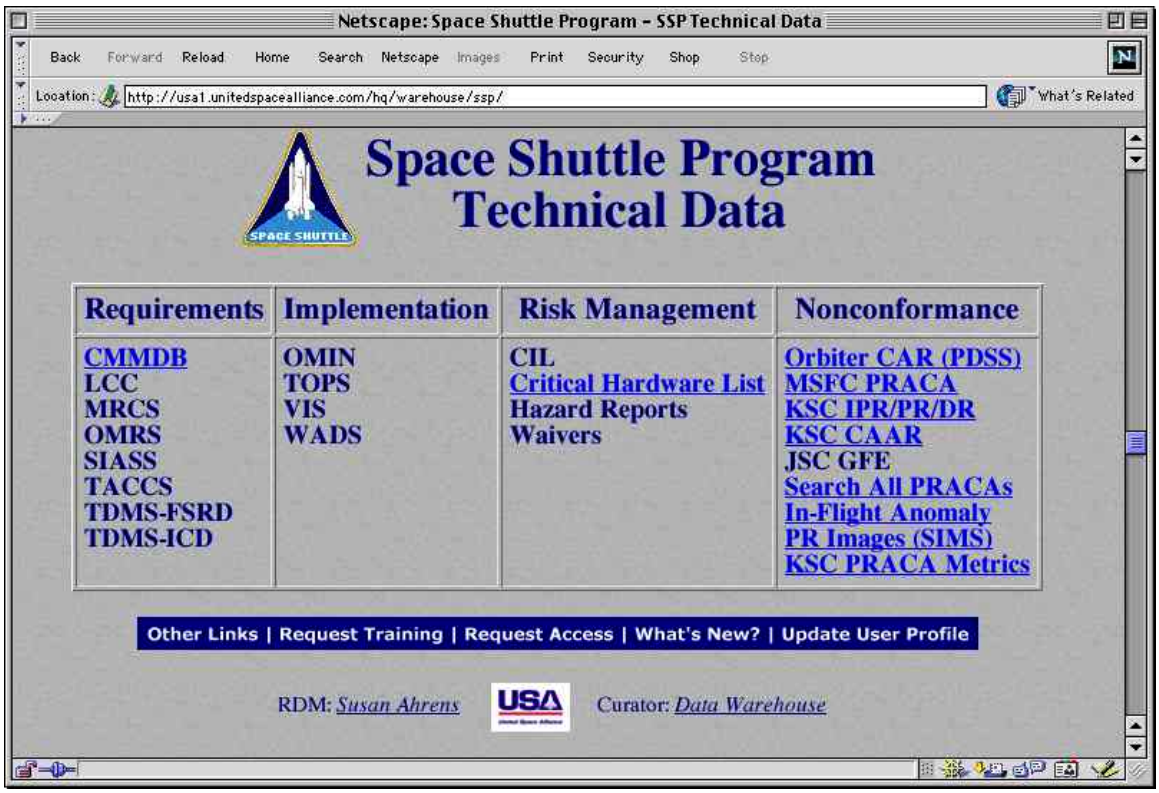

Figure 18 - ADAM User Interface

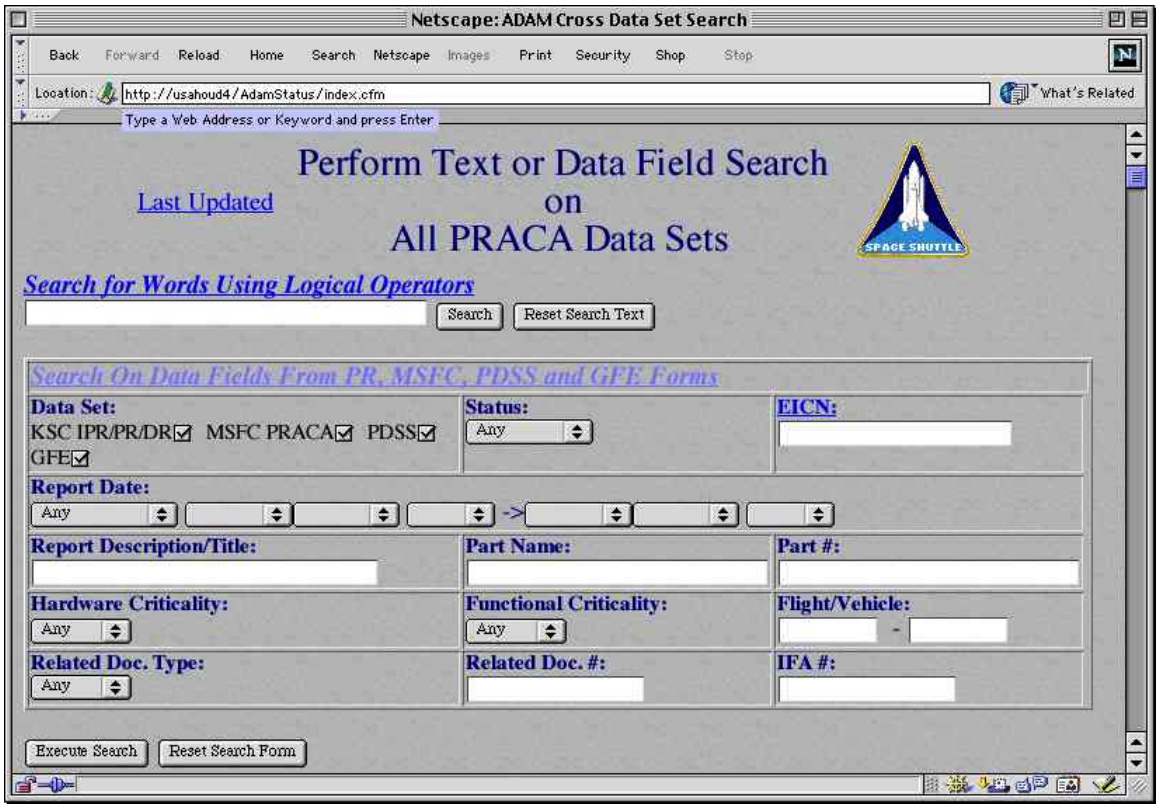

Figure 19 - ADAM Cross PRACA Query

The following figure shows an example of ADAM's trend plotting capability:

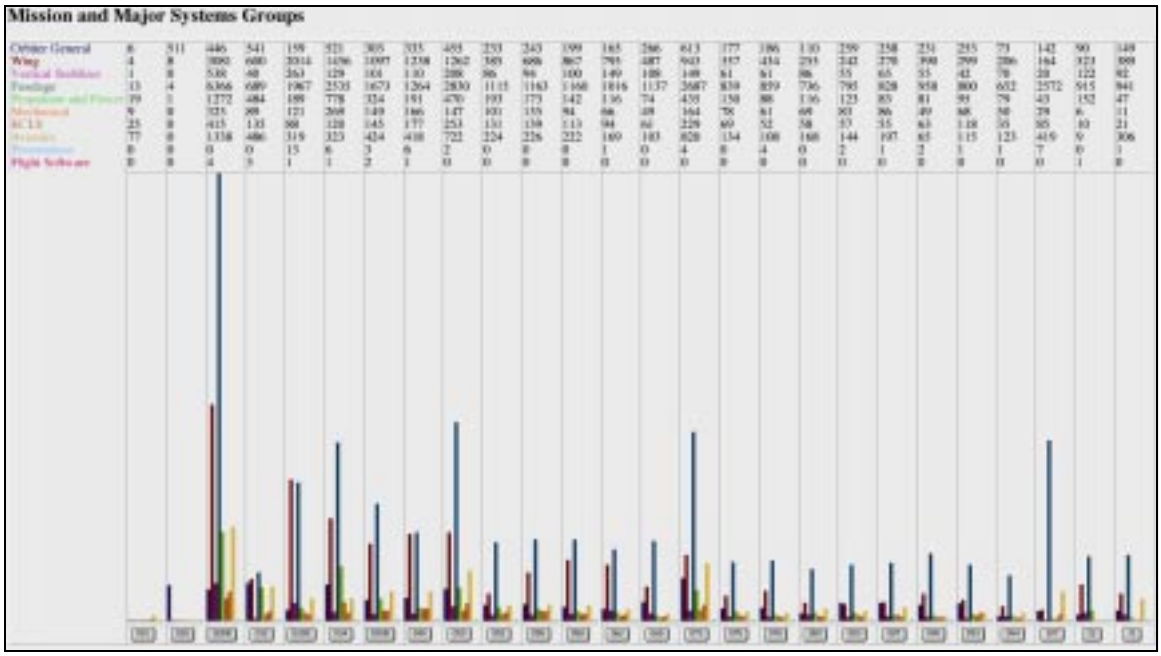

Figure 20 - ADAM Data Trending

ADAM's User Interface is a good example of a web-enabled and standardized interface across multiple databases. The ADAM, and MSFC UPRACA, have some degree of commonality in their design but the implementation of navigation is different. Unfortunately in order to query the PRACA source databases directly a user would need to know and be familiar with all of the PRACA systems' UIs.

3.2.2 Database and Data Management Findings

The team interviewed the various users and evaluated the PRACA systems databases where possible. In the case of the JSC government-funded equipment system and the KSC group support system the team did not achieve hands-on access, due to the team's remote location exclusion from the firewall-protected LAN (security model) and the user interface being designed for local access only.

The team made the following observations with regard to the databases and data management:

- The PRACA systems have fairly common approaches to database architecture and implementation:
  - All of the databases are relational with "report number" (or its field name variant) being the most common field across tables.
  - The smallest architecture is based on 12 primary tables.

  - Commercial off-the-shelf (COTS) database applications are used, with Oracle being the most common application chosen.
- The databases are deployed on PC Compatible computers running the Windows NT OS or on Unix (Sun or HP) systems. SPDMS runs on an IBM mainframe computer.
- None of the databases are currently taxing system performance.
  - JSC's PDSS is the largest (known) database at ~5 GB
  - JSCs GFE is the smallest at ~10 MB
- The oldest systems hold data that was created in 1974.

A summary of comparison information for the various PRACA systems Database Implementations is presented in the following table.

PRACA Database	Application Vendor	System OS	Host System	DB Size	Date created
PDSS	Oracle 7	NT 4	PC compat	~5 GB	~1974
GFE	MS Access 97	NT 4	PC compat	~10 MB	~1974/1998
KSC	SQL/DS	VM	IBM 9000	unknown	~1978
MSFC	Oracle 7	Solaris 2.6	Sun	~230 MB	~1978
ADAM	Oracle 8	HP-UX	HP V2200	NA	~1994/1996

Table 7 – Database Comparison

Overall, the PRACA systems lack formal documentation to support the design and implementation of all five subsystems, including ADAM. This means either a partial or total a lack of entity relation diagrams, data dictionaries, and database requirements documents. Some systems, like the MSFC UPRACA, were better documented than others.

3.2.2.1 JSC's PDSS

The Orbiter database was originally implemented in DB2. The PDSS utilizes several process models and a single database. The Orbiter PRACA process models include process flows for the initial CCAR/TCAR decision and the subsequent processing of these problems. There are twelve primary database tables with several additional tables to support applications processing, codes, and general database support. There is one entry in the common table for each problem record. There are repeating entries in five other tables for each problem record. There are six tables that contain narrative text information. The field JSC_REPORT_# is the unique identifier for each problem record and exists in each table.

JSC's PDSS 12 primary table relational architecture is shown in entity relation diagram form below:

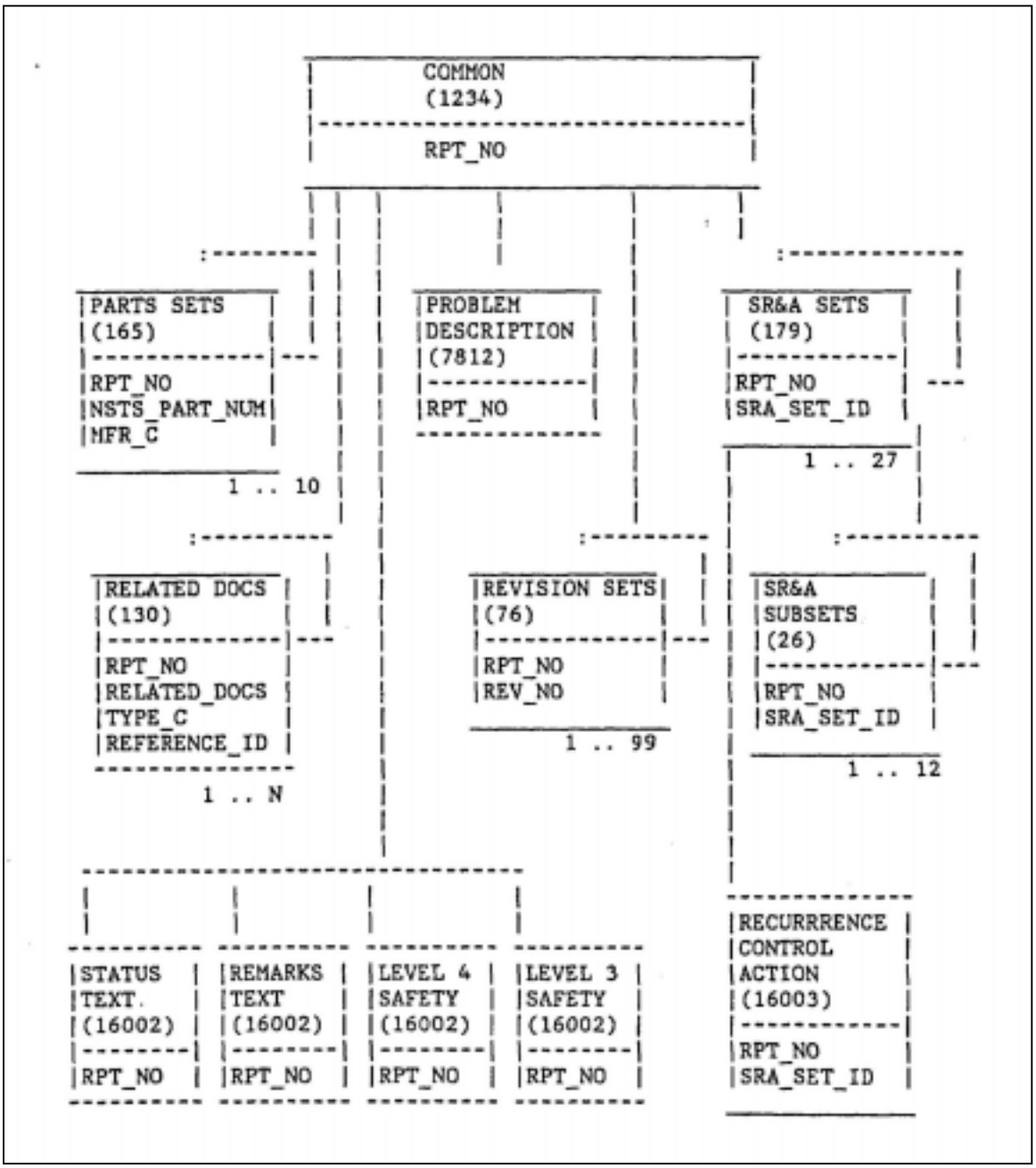

Figure 21 -NASA JSC Orbiter Database Schema (Original DB2 Architecture circa. 1988)

3.2.2.2 JSC's GFE

The GFE database was originally part of the Orbiter PRACA system. Like PDSS, the GFE data has followed the Space Shuttle development,with the earliest data in GFE originating in 1974 when PDSS was implemented in DB2. The GFE data were separated out of Orbiter PRACA during the PDSS Oracle upgrade in the 1997-98 time frame. This upgrade left two separate data systems (GFE and PDSS) resulting in separate data

management responsibilities. JSC's GFE 12 primary table relational architecture is legacy from the original DB2 design and it shares this common architecture with PDSS. The MS Access .mdb database tables view form is shown below:

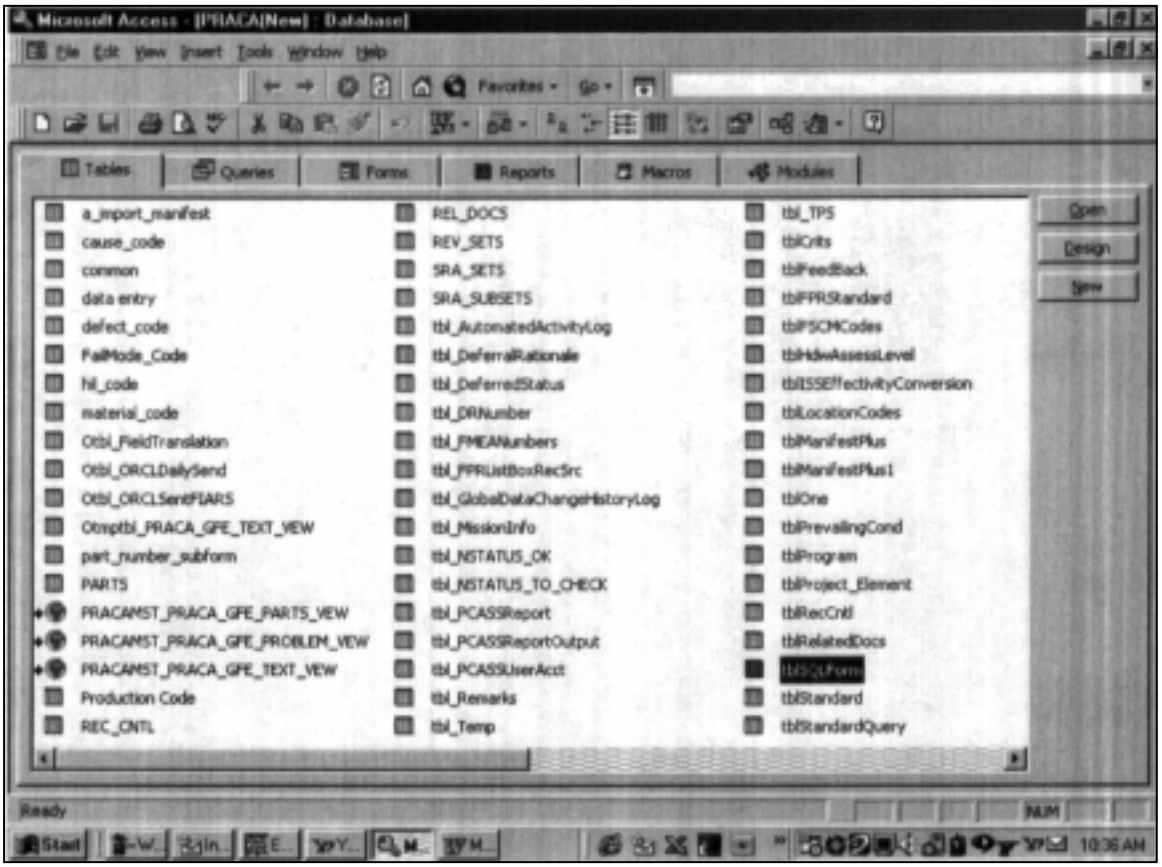

Figure 22 - JSC GFE Database Schema [S. Ferguson]

3.2.2.3 KSC's SPDMS

A relational database SQL/DS is used on the SPDMS to manage the PRACA data at KSC. The SPDMS holds at least nine separate databases for various group operations functions. For the PRACA database, there are 35 primary and support tables. Common fields are "Reference_Report_Number" and "USER_ID". KSC's SPDMS VM relational architecture is larger than the others and requires three figures to present all the tables. The main figure (1 of 3) is shown for comparison to the other database designs in the figure below:

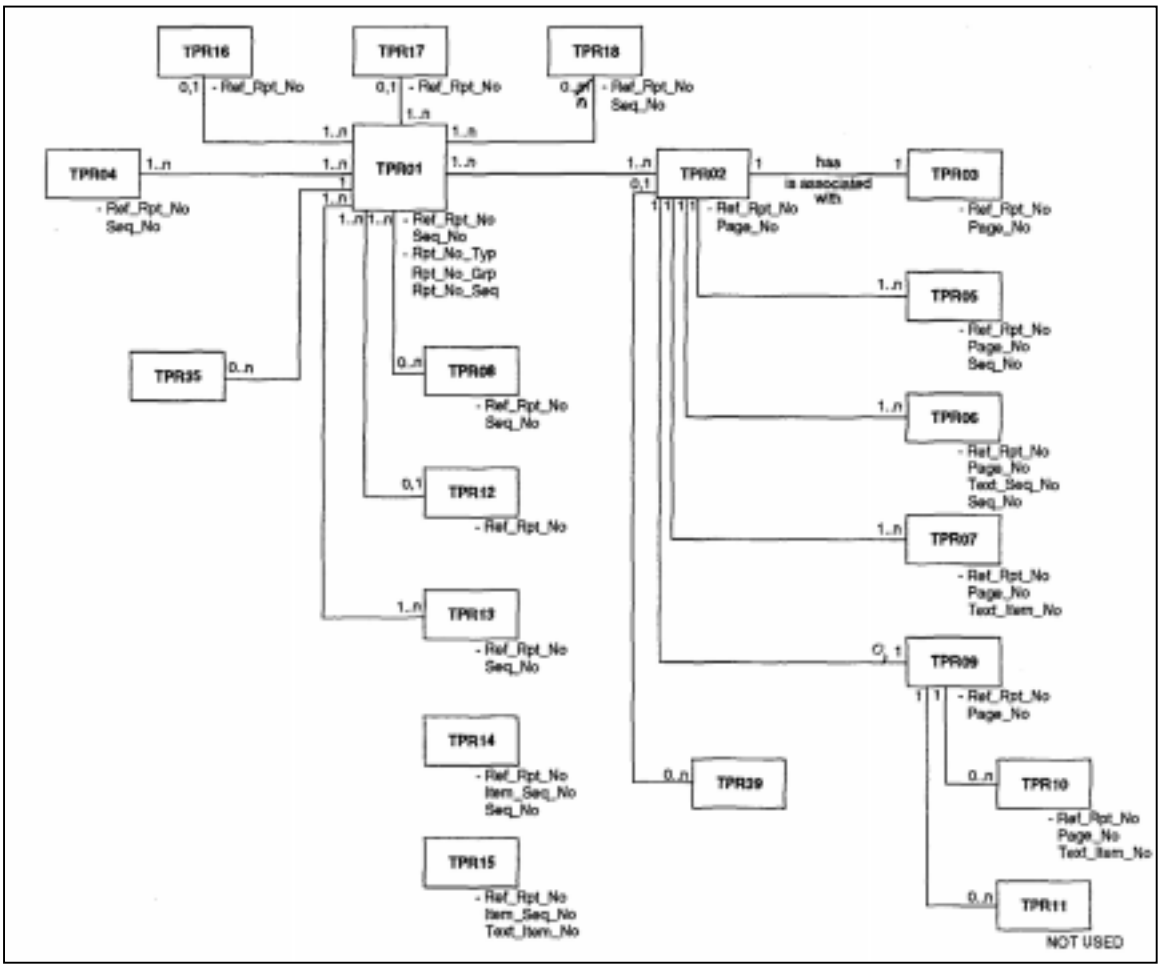

Figure 23 - SPDMS Database Schema (1 of 3) [D. Mondshein]

3.2.2.4 MSFC's PAS/UPRACA

The MSFC Problem Assessment Systems UPRACA is based upon the Oracle 7 database. It has approximately 18,000 problem reports and in excess of 900,000 records. This sixteen table database is approximately 230 megabytes in size, with the whole UPRACA database able to hold up to 5 gigabytes of data. All tables share the common field "MSFC_REPORT_#". The UPRACA relational architecture is shown in entity relation diagram form below:

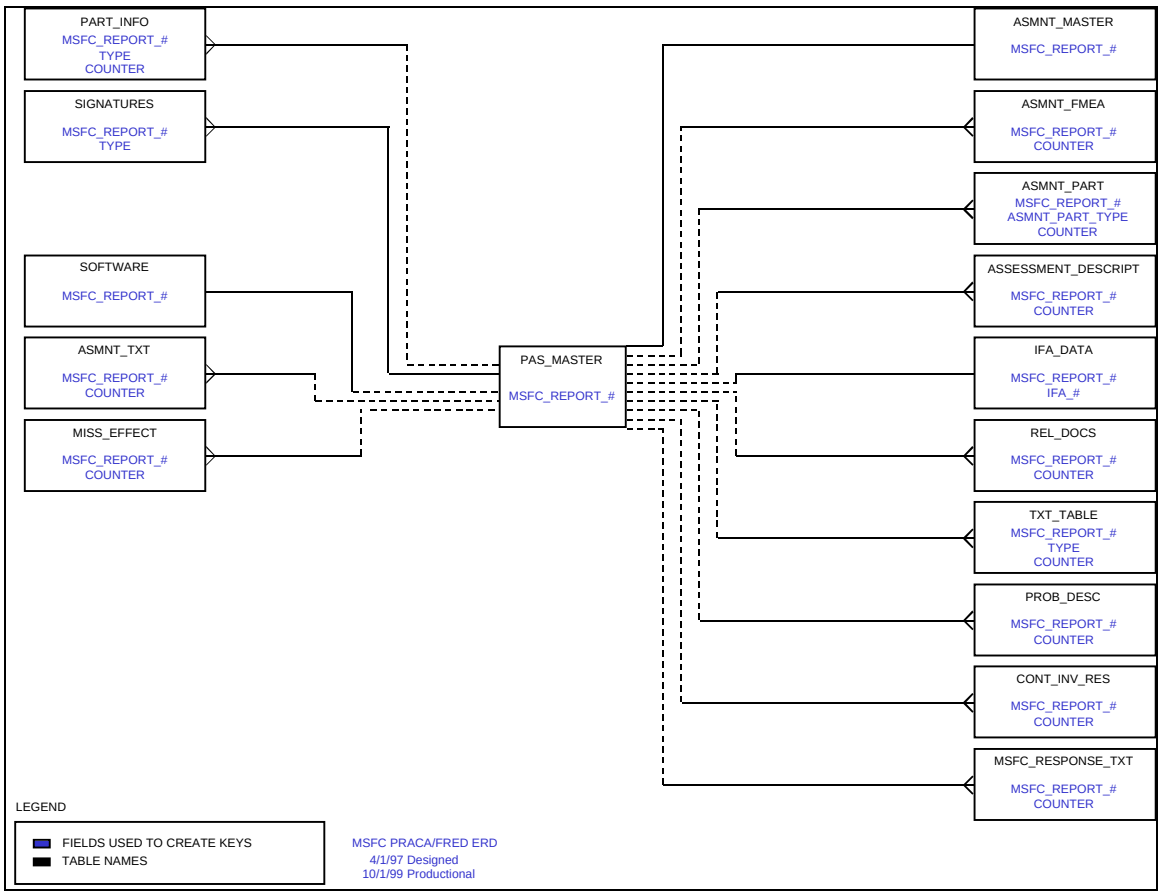

Figure 24 - MSFC Launch System Database Schema

3.2.2.5 USA's ADAM (IPAS/WebPCASS)

The ADAM database is implemented using the Oracle 8.0.x application software on the HP-UX system. There is no data warehouse schema or data naming convention that is consistent across all of the various PRACA system data. Ideally, all data relationships should be correlated and cross-referenced; however within ADAM there are no keys to show the relationships between the data fields. The ADAM design documentation lacked any type of keys (primary and foreign). Due to the lack of a unified PRACA data naming and database schema from all of the separate PRACA systems, ADAM is largely unstructured and very limited in capability.

The original intent of ADAM was to act as a data warehouse that would have been able to take end-user's queries against all of the PRACA data and retrieve the associated detailed results. According to our findings, ADAM is a front-end transaction traffic controller that directs user's request based upon a fixed prefix entity identifier via the database mechanism (e.g., physical infrastructure of the entity and property implementation).

ADAM does not have a naming standard for entities/attributes within the database. There is no unified or overall database schema for the various PRACA tables within the system.

The entity relationship (E/R) diagrams that were provided for ADAM were done in unfamiliar E/R standard notation. Each of these diagrams indicated unintentional flaws in the structure. Currently, each of these subsystems is comprised of entities and properties, but no relationship nor subtype.

A metaphor for the current state of the ADAM data warehouse is as follows: Imagine several teams of people each providing several bound sheets of paper, of various sizes and format, written in a particular language. Taking all of these bound groups of paper and unbinding them, and stacking them into a book is equivalent to the state of ADAM and the Project PRACA data currently. The book that represents ADAM has no table of contents, no index, and each sheet of paper is of different size with a different language written on it.

ADAM developers have recently started populating a data dictionary (a common language in the above metaphor) in ADAM that contains descriptions for the data in the individual datasets (sheets of paper) and more importantly, how the data from the different datasets relate to one another (an index and table of contents). A front end for this data dictionary is not yet available. Establishing the commonality between the data sets was very hard and has yet to be validated. ADAM can cross-reference a KSC PRACA “part_prog_no” column to a PDSS “partno” column, but if the two systems are not using standardized part numbers as source data then the query is fruitless. Although part numbers are not the ideal example, there are a lot of other data that is non-standard and poses similar problems.

3.2.3 Network and System Architecture Findings

As described in the Approach section, the team evaluated the System Architecture by considering several aspects including:

- Server technology
- Network security implementations (firewall, proxy, trusted host, etc.)
- Center-to-center communication techniques
- Technology maturity levels relative to state-of-the-art.

The team made the following observations with regard to the Systems and Networks:

- The accesses to the PRACA databases are via PC Compatible computers running Windows NT or commercial UNIX systems (Sun or HP).
- None of the database administrators report that they are taxing system performance.
  - The disk space requirements are relatively low.
  - The query speeds are satisfactory (as evaluated by the user community).
- All of the databases are networked.

  - It would be possible to connect to any of the databases from an Internet-connected computer
  - The firewall implementation provides access restriction but the security effectiveness is not clear.
  - There is no SSP document that identifies access restriction design requirements.
  - There are no System level processes to monitor for security violations.
- All of the systems have upgrade potential to state-of the art capability.

PRACA Database	Host System/OS	DB Size	Network	Security	Password UID	Technology Maturity (Low-Med-High)
PDSS	PC com. NT 4	~5 GB	LAN	Firewall Trusted client	Write: Yes Read: no	Med
GFE	PC com. NT 4	~10 MB	LAN	Firewall Trusted client	Read: No Admin: Yes	Low
KSC	IBM 9000 VM	Unknown	LAN	Firewall Trusted client	Yes	Low
MSFC	Sun Solaris 2.6	~230 MB	LAN	Firewall	Yes	Med
ADAM	HP V2200, HP-UNIX PC com. NT4	NA	LAN	Firewall	Yes	Med

Table 8 - Network and System Comparison

3.2.3.1 Security Issues

There are several security issues associated with the current networked implementations that are noteworthy:

- It would be possible to access any of the databases from an Internet-connected computer.
  - The firewall implementation provides machine level access restriction but the security effectiveness is not clear. (e.g., trusted client without user authentication does not preclude unknown user access.)
- There is no SSP document that identifies data security requirements and access restriction design requirements. As a result, neither the purpose of the security measures nor their effectiveness can be assessed.
  - The measures could be ineffective.
  - The measures could be unnecessary.
- There are no system-level processes to monitor for security violations.
  - There may be ongoing security breaches that are not being tracked.

- A random check of web site implementations was noted to provide potential security holes:
  - http://www.houston.ssd.bna.boeing.com/d331/pac/ is open to the public and gives an index listing.
  - http://usa1.unitedspacealliance.com/hq/ also gives a listing but it is not a public page.

3.2.4 PRACA Work Process Findings

To understand the PRACA data life-cycle (how it is created, used, stored, managed and updated) and the interrelationship with the human in the work process, a work process study was performed. Some of the findings of that study have been used in previous parts of this report. This section discusses two important general findings from the work process study (limited to the KSC PRACA data collection, and JSC Orbiter problem reporting closure processes):

1. The dependence of PRACA on people and the paper data record; and
2. The importance for PRACA of human factors and organizational issues.

3.2.4.1 Key Role of Paper and People in PRACA Work Process

PRACA is normally thought of as a collection of databases: however, the distributed nature of those databases, each managed by different groups, appears to contribute to a continuing supply of paper flowing through the system. Paper representations play the key role in the information flow process at several points. While this might not be surprising at the initial input stage, there are significant uses of paper at many subsequent stages of the problem reporting process, which are probably sub-optimal. Also, it is apparent that in more than one of these situations, the PRACA system relies heavily on key personnel to manage the paper trail and determine its disposition and follow up on the process.

This extensive use of paper (and supporting personnel) in the later stages of the process is important for two reasons: the cost of printing, filing, and transporting the paper records and the issue of accuracy due to transcription errors. There is always a possibility of error when data is re-keyed into the system. For example, while there is an electronic transfer of information from Huntington Beach to the Orbiter database, some information is also transferred to a web site and must be re-keyed.

3.2.4.1.1 Use of Paper in Initial Filing of Problem Reports

The following is a description of how an initial problem report is filed at KSC during Shuttle processing, with an emphasis on the use of paper:

Initially, a nonconformance is discovered, usually by a technician in the course of their work, but sometimes by an inspector. The person discovering the nonconformance begins by filing an Interim Problem Report, Problem Report, or Discrepancy Report. Note that these are all filed using the same paper form; they differ only in the box that is checked for Field 1: Report Number. The form may be filled out directly on a computer located at the Test and Inspection Record (TAIR) station, but more often is filled out on paper. In general, technicians do not carry blank forms with them. They usually jot down the required information on a piece of paper they have with them, then go to the TAIR station, where they either fill out a paper form (KSC Form 2-151 shown below), or more rarely, directly on a computer-based form. We have been told approximately 80% of these forms are filled out manually, since many technicians are not comfortable using a keyboard, and prefer to use the paper form.

National Aeronautics and Space Administration
John F. Kennedy Space Center

1. Report Number
☐ INTERIM PROBLEM REPORT ____
☐ PROBLEM REPORT ____
☐ DISCREPANCY REPORT ____

PAGE ___ OF ___

2. Detected During	3. Work Area	4. End Item Control Number		
5. Work Unit Code	6. Part/Prog Name	7. Part/Prog No.	8. Ser./Rev No.	9. Qty

10. FSCM/Vendor	11. NHA/PN/Tape/Disc ID.	12. STS #/Eff.	13. Reported by (Name/Org)	14. Date

15. Software Problem Locator — Date ____ Time ____
☐ Dump ☐ Translator Output ☐ Line Printer Output ☐ Compiler Listing ☐ Other (Specify)

16. Item	17. Problem Description 17A. Validation

18. Crit. Skills	19. Eng. Change Req.	20. Constraints:	21. Crit	22. Resp Org.
☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No		
ITEMS:	ITEMS:	TO:		

23. Weight Reqd	24. Retest Reqd	25. Hazardous OP	26. MR Reqd	27. Time/Cycle	28. Fracture Crit
☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
ITEMS:	ITEMS:	ITEMS:	ITEMS:	ITEMS:	ITEMS:

29. Item	30. Disposition/Cause/Corrective Action	31. Tech	Contr QA	Govt QA

		32. System Restored (Signature) Date	33. Final Accep Date			

34. Data Code	35. Repl. S/N	36. Related Reports

37. RC Action Reqd	38. RC Constraint To: (Signature Date)	
☐ Yes ☐ No		
ITEMS:	39. RC Closure (Signature) Date	

KSC FORM 2-151 (REV. 2/96) PREVIOUS EDITIONS ARE OBSOLETE

Figure 25 - KSC Problem Report Form 2-151

Because the form is usually not filled out in the physical proximity of the problem site, the technician may have to make several trips back to the problem location to get information omitted in the first round of note taking on the nonconformance. There are a number of fields which are particularly likely to be forgotten or misidentified. These include:

- 4. End Item Control Number;
- 10. FSCM/Vendor; and
- 11. NHA (Next Higher Assembly)

(Note: These candidates for particularly error-prone fields come from interview data. Additional observational data would support or reject these candidates and suggest possible further problem fields.) Because the TAIR station is physically located at a considerable distance from the Shuttle itself, although within the same building, each trip back to get the required information to fill in a forgotten field demands significant time for the technician to climb in and out of the Shuttle and then travel up and down three flights of stairs to the TAIR station.

Figure 26 - KSC TAIR Station

The person discovering the problem fills out the relevant items for fields 1 – 17, and then gives the form to the TAIR station. TAIR station personnel enter the data. They then initiate a scheduling process, which requires an engineer to determine the potential constraints imposed by the nonconformance, criticality of the nonconformance, and disposition/corrective action for the nonconformance. Engineers and inspectors work with paper copies of the form, and signatures and inspection stamps located on the paper form represent their decisions. (Note: There is an inspection process for repairs. In addition there is an inspection process for the Problem Report forms. Additional

observational study could determine exactly how these processes work, and what their impact on PRACA data is.)

When the nonconformance has been dispositioned and the form completed, the final step before the report is closed is a code check, which is represented by field 34 of the Problem Report form. This is done by a USA engineer, who determines whether the document was processed correctly. This check is represented by 10 digits, which code proper filling out of specific fields in the form.

3.2.4.1.2 Paper Processing by the SSP

John Mulholland, Deputy Manager for Operations in the Space Shuttle Vehicle Engineering Office, is an ultimate decision authority in the PRACA system(s). Mr. Mulholland uses CARs (responding to PRACA PR's) to make go/no-go decisions on Shuttle flight safety that are based on issues of criticality, specifically "Crit" 1 and "Crit" 2 items. It is interesting the extent to which his use of the PRACA data relies on paper: printed-out database forms, printed out emails, yellow Post-It™ Notes, etc. This section explores the reliance on paper in this process.

When a complete failure analysis report is assembled, the Subsystem Manager (SSM) and the Problem Resolution Team (PRT) use it to create a problem disposition to a Corrective Action Report (CAR). (Note: Further fieldwork could determine how much of this report involves the physical assembly of pieces of paper, reports, test outcomes etc., which are then attached to the CAR and where those reports are ultimately filed.) Once all of this information is assembled, it is sent to the Boeing Problem Action Center (PAC) office in Huntington Beach. They verify that all information is included, and the package is sent electronically to the local Boeing office at JSC. That office makes a hard copy/copies of the report material, which has also been entered into the PDSS database. At the local Boeing office, personnel also load much of the information to a website, a process that requires some re-keying. The hard copy/copies are then separated out for circulation to required engineers and personnel at various sites at JSC, whose signatures are required to close out the CAR.

In this process, the system relies on key personnel to sort the material, make decisions about who should get what information, and physically walk the material through the system. CARs will be separated out and distributed to responsible engineers, whether at NASA in the Engineering Directorate or at USA, System Area Managers (SAMs). According to criticality, they will be taken to Mr. Mulholland in the Orbiter Project Office. The documents are placed in folders according to a prescribed color code, and physically walked or driven to the appropriate offices by support staff.

Since Boeing has begun loading the material to a website, some engineers have taken the opportunity to review the material on-line before the hard copy arrives on their desk. This action is speeding up the review process somewhat. However, the time-consuming, physical process of driving/walking these copies from the Boeing office to the USA office and to other sites in various buildings at JSC is still in use.

If Mr. Mulholland approves the problem resolution, he signs a paper copy of the form. The documentation package gets picked up by staff from the local Boeing office and is hand carried back to that office where the information is entered into the system and the CAR is closed.

If Mr. Mulholland does not approve the report or he has questions for the PRT or SSM, he generally indicates that on a yellow Post-It™ Note and places the hard copy back into the system by placing it in his office outbox, where it gets physically picked up by Boeing personnel and taken back to their office. If Mr. Mulholland is able, he will often call the SSM with the question, but this is not always possible, so the hard copy must go back to system with his questions attached. Once back in the USA/Boeing office, support staff will email the appropriate engineer with Mr. Mulholland's question. That email and any replies will be attached to the package as hardcopy attachments, at which point, the whole package is then physically taken back to Mr. Mulholland for his approval and signature.

3.2.4.2 Types of Work Practice Issues

In our initial study of the PRACA work practice (limited to the KSC PRACA data collection, and JSC Orbiter problem reporting closure processes) we found a number of problems and areas for improvement. These fall into three categories: Work Practice and Human Factors issues, Organizational issues, and Technical issues. We discuss these in turn.

3.2.4.2.1 Work Practice and Human Factors Issues

The KSC technicians and engineers have not received training in what PRACA is, or does, nor in what kinds of information are being requested for PRACA and why. The PRACA purpose is learned as on-the-job training in how to fill out a PR form. The trainee is usually most concerned with two things: how to fill out the form so the work will be completed correctly; and how to fill in the form fields so that the form will not be rejected by inspectors. As mentioned above, this can lead to an apprenticeship in learning what kinds of information will be accepted, rather than in learning how to provide accurate information.

In general, KSC technicians and engineers do not fill out a PR form at the site where the problem is located. This can lead to several trips back and forth from the problem site to determine part numbers, exact location of problems, physical sketch of problems, etc. Inaccuracies can be introduced in every trip.

There are a number of local differences in how different organizations fill out Problem Report fields. Some of these differences are directly relevant to the work of that group, while some of the differences are historical. For example, some groups use a hazard assessment stamp for block 30. Engineers must initial and check this. Use of this stamp

is not necessary for the final report. Rather, it is a local adaptation that allows for the establishment of safe conditions during repair.

Some groups describe nonconformances on a problem report using the syntax: "Is X" "Should be Y". Other groups simply rely on the heading of the field to indicate that the descriptions refer to the problem and its suggested disposition. These differences are not important in themselves. However, they could become quite important in an attempt to do natural language understanding of the historical backlog of problem descriptions and dispositions. (At least one such project is underway as collaboration between KSC and Central Florida University.)

Local names for parts and materials may be different from the names required on the Problem Report. For example, at KSC, technicians may describe tile material as "Nomex," the generic name for the material. The required terminology for the report is "FRSI," referring to Nomex that has received specific treatment to serve as Shuttle tile material.

The PRACA PR must include a page count of how many pages are contained in the associated documentation. However, there are ambiguities in whether appendices should count in the page count.

3.2.4.2.2 Organizational Issues

We have learned that different organizations may categorize problems differently. For example, the Palmdale facility is said to categorize some wiring problems as "fair wear and tear," which KSC would treat as non-conformance requiring a problem report.

During the interviews, it was suggested that one measure of organizational accountability is the number of problem reports filed. This would tend to create a climate where reducing the number of problem reports filed, by tending to identify a nonconformance as a less significant category, has incentive. This is an important issue for further investigation

3.2.4.2.3 Technical Issues

PRACA assumes a strict hierarchy of problems, based on the tree structure of the Shuttle assembly. This makes it difficult for the inspectors to document or describe problems that result from interactions between components in different assemblies or systems. Note that two components may be distant from one another on the tree-structured representation of the Shuttle's part, while being within close physical proximity, and hence liable to physical interaction.

The TAIR station contains all the documentation of any kind that travels with a Shuttle as it is processed. This is a literally a truckload of paper, which travels with the Shuttle in wooden "coffins" from building to building. Some of these consist of Problem Reports, though most of them are paper records of routine processing.

Figure 27 - KSC Records and Processing

The paper movement at KSC is similar to the SSP Paper management process described earlier. At KSC an enormous amount of paper is physically moved through the work process system, at a point when most of the essential information already resides in the electronic database.

At KSC there have been experiments to use personal data assistants (PDAs) for filling out PRs, rather than paper. Dan Mondshein reported preliminary success, however, the early PDAs lacked robustness and became obsolete. Additionally, the use of PDA's has not and was not budgeted into the recurring costs for replacing paper. We have been told that there are plans try again perhaps using the Palm PDA platform.

4.0 Recommendations

In order to recommend modifications, upgrades, and enhancements to the SSP PRACA systems, we must establish two things: first, what PRACA currently is; and second, what PRACA should be. This study has endeavored to identify the current state of PRACA (i.e., what PRACA currently is). As for what PRACA should be, there are three fairly distinct mental pictures emerging from the team's interviews with the PRACA workforce, SSP management, and NASA senior management. These are:

1. The Project/Element domain expert view:
   PRACA should remain a collection of relatively simple databases that support the work process and record-keeping functions. These databases are designed primarily to support the domain experts who are responsible for reporting Project/Element status and trending to the SSP. The domain experts would prefer that the SSP continue to rely upon the domain experts for data extraction, filtering, analysis, interpretation and reporting from the PRACA databases and other sources.
2. The Fund Source (SSP/Code M) view:
   PRACA is a multi-center data system that is vital to the SSP mission. The domain experts' role in the PRACA system is consistent with the team problem resolution approach and is not seen as a potential problem. Ongoing reviews and relatively stable workforce will sustain the system's viability into the future. Additional work on PRACA should be justified based upon new capability. Doing the same thing better, faster, or cheaper is not necessarily a high priority for funding.
3. The NASA Information Management view:
   PRACA should be a state-of-the-art data warehouse capable of data mining and advanced data analysis and trending using a simple and uniform point and click interface. The system should preclude data errors, incomplete problem tracking, and catch potential problems that might otherwise go undetected (e.g., "escapes" and "diving catches"). The system should reduce the sole dependence on domain experts and corporate knowledge, placing the power of top-level knowledge and information in the hands of anyone with access to the system via a simple user interface. Additionally, advanced data mining capabilities would support the SRQ&MA analysts to improve the speed and accuracy of their assessments. With the Shuttle expected to fly another 25 years, the system architecture must be dynamic and capable of overcoming changes in workforce, technology, and flight rate. The system should be enhanced to provide a foundation enabling the future implementation of a safety and risk prognostics capability. The system should serve as a model and pathfinder for the Agency.

As we have noted in previous sections of the study, there is no overall SSP PRACA owner and vision declaration for scope and functionality. The general vision of capability proposed in the NSTS 07700 volume XI is not being fulfilled with the present PRACA systems.

The Study team has chosen to present its recommendations with attention to the identification of an owner, the decisions yet to be made, and the assumption that the NASA Information Management view of the PRACA system should serve as a goal for the final system state and our recommendations. Sensitivity to the Project and Fund Source views was maintained but as secondary considerations. Given this attention and assumption guideline, this Study has identified several recommendations for modification, upgrade, and enhancement of the SSP PRACA System. The recommendations are organized as follows:

1. A set of general recommendations.
2. Specific recommendations addressing the four technical assessment areas (UI, Database and Data Management, Network and System Architecture, and Work Process Study).

These recommendations are discussed in the following sub-sections.

4.1 General Recommendations

4.1.1 Global Perspective

The SSP-identified PRACA owner needs to make a global assessment of PRACA with both a short-term and long-term view. It is important to answer vision-defining questions such as:

- Is PRACA sufficient for the SSP needs? If so, for how long?
- Is PRACA to be a cutting edge information management system? Is it to serve as an example for Agency emulation?
- Is PRACA to look beyond SSP focus to leverage other safety and reporting systems? (Aviation Safety Program, Commercial aviation scheduling and planning systems, model-based reasoning systems, digitized Shuttle systems, other NASA PRACA systems, etc.)
- What is the evolving role for PRACA looking into the next 25 years?
- What is the relationship of PRACA to the changing NASA workforce? And how does that impact PRACA functionality over time?
- Is PRACA to be the foundation of a Safety and Risk Prognostics System for the SSP?

It is equally (if not more) important to answer design questions driving the requirements such as:

- Who is the owner of the system?
- Who are the customers for the system's data?
- Who are the users of the system?
- Who are the managers of the system?
- What skill level(s) is expected of the owner, customers, users, and managers of the system?
- What is the security level of the data in the system, and what is the desired visibility in the community?

- How large a dependence on expert knowledge and human interpretation is acceptable?
- Is it permissible/desirable to use data outside of PRACA (and PCASS) or should PRACA be the sole source of data access?
- What are the roles of the Program office as an owner, user, and a customer of PRACA information?
- What is the role of PRACA at the data collection level? At the Program/Element level?

Once these and other similar questions are answered, the SSP should clearly articulate its vision and train and/or inform personnel in all of the levels of the PRACA system.

4.1.2 PRACA as an Element of Safety and Risk Prognostics

One of the unrealized possibilities for the PRACA database systems is as a foundation for a Safety and Risk Prognostics capability. Prognostics in this sense go beyond simple data trending, to provide a true predictive capability that could greatly enhance the decision-making capabilities of the SSP and the safety of the Shuttle.

Recommendation:

- Establish a plan for PRACA system evolution that will enable the development of a future Safety and Risk Prognostics capability.

Impact:

- Improve the breadth and depth of the SRQ&MA analyses performed by the experts in a given time frame, as well as ensure the high quality of the PRACA data for such analyses to be made.
- Provide a manager-level overview and quick look assessments of Shuttle safety and risk data.
  - Enable SSP management to be more proactively involved and up-to-date on the performance and safety trade-offs for the Shuttle fleet.

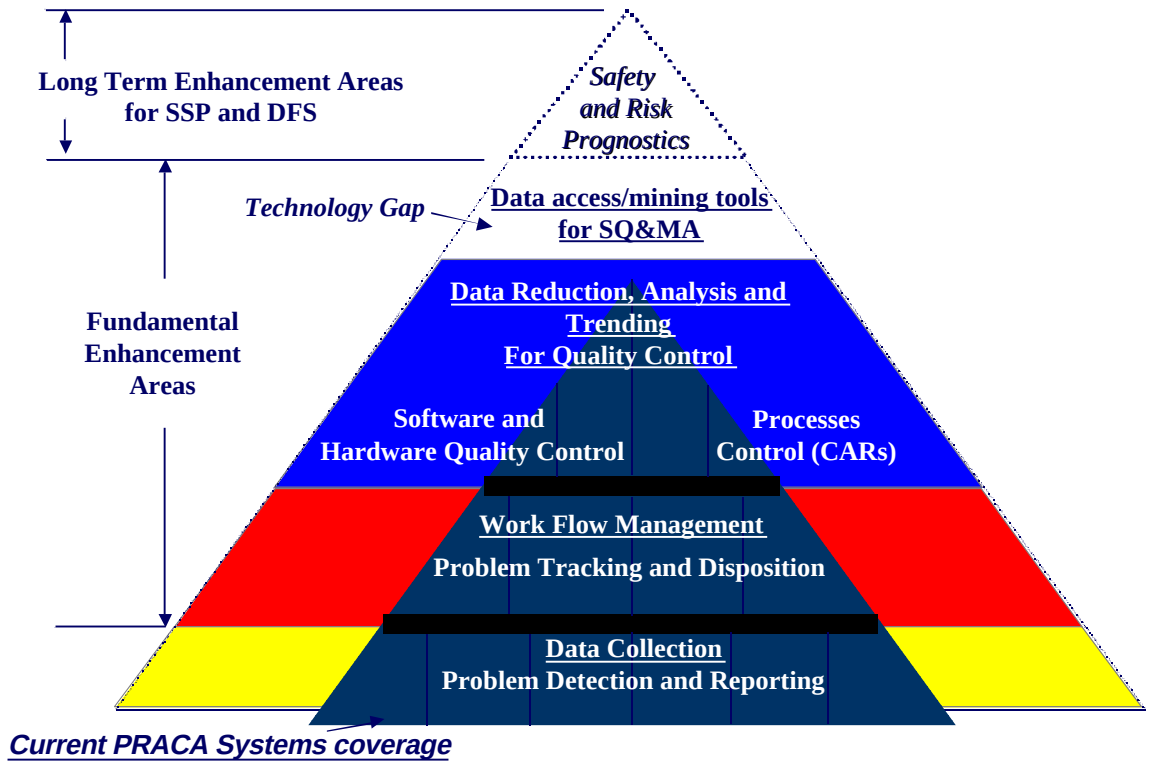

Figure 28 - PRACA Data Use Concept

As noted in the figure above, a technology gap exists in the current PRACA technology "pyramid." This technology gap is currently compensated for by the use of domain experts to manually search, interpret, filter, and process the data into knowledge for the SSP. This technology gap should be eliminated by:

1. Implementing improvements to the PRACA systems in the fundamental enhancements areas as shown in the figure
2. Implementing advanced data access, data mining, and unified user interfaces.

We believe that an improved and enhanced PRACA System could radically improve the breadth and depth of the SRQ&MA analyses performed by the experts in a given time frame, as well as ensure the high quality of the PRACA data for such analyses to be made. Additionally, the future PRACA System would provide a manager-level overview and quick look assessments of Shuttle safety and risk data. This will enable SSP management to be more proactively involved and up-to-date on the performance and safety trade-offs for the Shuttle fleet. Specific recommendations to do this are addressed in section 4.2.

4.1.3 Update of PRACA Requirements

Since the delivery of the SIAT report in December 1999 and the initial ARC PRACA review in January 2000, the SSP created the PET to reassess and revise the NSTS 08126 requirements for PRACA. In conjunction with this activity, the USA Integrated PRACA

Team has addressed many of the underlying processes and motivations for the various PRACA systems under its control. These activities do several important things:

- They unify some of the reporting requirements.
- They enhance some of the access requirements.
- They respond to multiple SSP and USA audits and reviews and address the SIAT report concerns and the informal ARC Study comments.

It is also ***critically*** important to answer the design questions driving the requirements, from section 4.1.1 that have not been completely addressed by the aforementioned SSP and USA activities.

4.1.3.1 PRACA Owners

The creators or Project-level managers of the PRACA systems do not yet view PRACA data as a program-wide resource. An overall "PRACA System" as an organizational or technological entity does not exist, and was not required by the NSTS 08126 Revision G document. The JSC PET has rewritten and enhanced the NSTS 08126 document to a Revision H. Revision H better reflects desired scope and global functions required of the SSP's PRACA system. The Space Shuttle Program Review Control Board is expected to approve Revision H in the summer of 2000.

The SSP has identified a Shuttle Program PRACA Owner and USA has identified an internal PRACA owner. The team recommends that these owners take the action to declare the vision for the "PRACA System" and its evolution over the next 25 years. The vision declaration should create a concrete image in the minds of the PRACA workforce, from the data collectors through the SRQ&MA analysts to the SSP management office.

4.1.3.2 Program-Level Access

As we discussed in a previous section of the study, the existing "PRACA System" is not sufficient for Program-level data mining and SQ&MA assessment. The SSP currently meets the necessary constraint of having enough problem reporting data and insight by relying on a set of domain experts possessing extensive knowledge of the Shuttle subsystems and the PRACA data, and who have access to additional non-PRACA (formal) data. These experts produce consolidated reports and summaries for the SSP office from which the SSP performs its tasks and formulates decisions. This sole dependence on expert knowledge and domain experts has shielded the SSP office from several PRACA deficiencies, including:

- PRACA data alone does not provide enough information for Program-level trending and data mining applications.
  - There are multiple data sources on maintenance, repair, corrective actions and engineering dispositions (CARs, hazard reports, engineering databases, expert knowledge, etc.) not included in the PRACA systems (or even PCASS) and unavailable to the Program Office.

- Every PRACA system is unique and designed primarily for Project/Element (subsystem domain) use. Program use of the systems and their data are mainly handled as design patches to the systems.
- USA's ADAM is incomplete and unable to act as a data warehouse supporting cross database data mining. A proposed KSC/USA WebPCASS based upon the existing ADAM structure is currently proposed. This is a good first attempt to provide unified PRACA data and some associated information, but needs to go much farther.
- Generating SRQ&MA reports is an extremely time and labor intensive activity requiring specialized knowledge and much massaging and cleaning of PRACA data.

To improve Program-level access to the PRACA data, we recommend that the current PRACA system be replaced or significantly upgraded.

Recommendations:

- Clearly identify (list) the Program-level PRACA tasks from a Program-wide perspective
- Establish requirements for a "PRACA System" that performs SSP level PRACA tasks (data retrieval, mining and trending needs). This action should be performed without consideration of current PRACA capabilities.
- Design a PRACA System that satisfies these requirements.
- Either a) Implement this new system or b) Initiate a modernization activity to upgrade the current PRACA systems and designs to satisfy the requirements.
- Replace or enhance the existing WebPCASS proposal based upon the above decisions.

4.1.4 PRACA Assessment Areas Recommendations

As a foundation for the new PRACA system design, the team has identified specific deficiencies and recommended actions for each of the four assessment areas identified in our Study approach. It is important to note however, that we believe the Program-wide vision for PRACA (i.e., "what PRACA should be") must precede system technology changes.

With regard to the assessment area of functional capabilities and the upgrades recommended, it is our opinion that a PRACA Enhancement Project should

- Satisfy all the Program Offices task-based requirements (see previous section);
- Satisfy the Project/Element (subsystem domain) work flow management requirements;
- Meet all NASA data security standards;
- Increase the user base through ease of access and intuitive user interface;
- Incorporate expert knowledge capture to assist in correct data interpretation and to reduce dependency on human corporate/institutional knowledge;

- Simplify system management and support requirements;
- Integrate with other Shuttle data sources to enable Data Mining in support of Risk Assessments;
- Provide advanced IT capabilities for Trending and Analysis in support of SRQ&MA requirements;
- Provide a migration path to a true safety and risk prognostics capability for the SSP.

4.1.5 User-Interface Recommendations

In the findings, we noted that all the systems have different user interfaces.

Recommendations:

- Create a User interface for querying PRACA data and generating basic and advanced reporting and Trend Analysis.
  - Implement a standard GUI across all systems. Use a widely distributed and supported web browser as the foundation of this interface.
  - Implement transparency to isolate the user from database-to-database navigation.
  - Implement a personalizable User Interface allowing customization of the interface to the needs of each User.
  - Provide collaborative capabilities to permit and encourage sharing and queries and analyses.
  - Create data mining and reporting tools to support both the advanced SRQ&MA analysts as well as the SSP management level overviews of the data.
  - Implement data mining and reporting tools to support the inspectors and assist in the assurance of data quality and integrity entered at the work flow management level.
- Implement standard user access control (security) across systems
- Require that all Safety and Risk data reports be generated using this system to enforce the migration of all necessary data into the PRACA System.

Impact:

- Reduced training, development cost and management overhead.
- Single UID and password provides access to all systems
- Increased visibility into PRACA data, yielding better error checking, increased knowledge base, and better-informed and timely decisions.
- Eliminates the SSP management sole dependence on external data sources and domain experts. All necessary data are migrated into PRACA (from the supporting databases and expert knowledge sources), eliminating this long-term vulnerability.

Note: The PRACA documentation states that PCASS has the role of integrating problem reporting systems from all Project elements and providing a closed–loop verification and

accounting process to assure resolution. In section 4.1.5.4, it states that the PCASS shall compile, formulate, and display trend data to identify changes in hardware and software performance, reliability, and supportability, and to define program requirements. This implies that ADAM (or the future WebPCASS) will integrate program element trend systems, perform analysis, and provide data formatted for management visibility. This is not what is currently done or possible in the current ADAM implementation, nor what is proposed for WebPCASS.

4.1.6 Database and Data Management Recommendations

In the findings, we noted that all the systems use relational database products but have different database implementations. The depth of documentation and requirements varied from system to system but generally needs much improvement. The PRACA systems were designed for Project/Element use. Program-level reporting and trending is heavily dependent upon additional external databases and expert knowledge. In addition, many current PRACA data fields in the databases are considered to contain questionable values and have "variable" definitions. This increases the dependency on "experts" to filter and interpret the data extracted from the PRACA databases.

Recommendations:

- Develop consistent database schema and structure, and common data field naming conventions and definitions.
  - Schema and structure should be designed to support SSP reporting, trending and data mining applications as well as to support the Project/Element work flow management.
  - Schema and structure should be well documented to preclude data interpretation errors and reporting errors.
- Standardize on a common COTS database application.
  - Oracle database is most commonly used in PRACA and would be a good choice.
  - Implement standard user authentication across systems.
- Extend the ADAM data warehouse to include relevant non-PRACA databases.
  - Data field naming (or mapping) should be consistent with the PRACA data fields, schema, and structure and should be well documented to preclude data interpretation errors and reporting errors.
- Require that all SRQ&MA reports be generated using these databases to enforce the migration of all necessary data into the "PRACA System."

Impact:

- Reduced development cost and database management overhead
- Enable common queries, data mining, and consistent ease of access to data
- Increased visibility into PRACA data yielding better error checking, increased knowledge base, and better-informed and timely decisions.

- Reduced dependence of PRACA System on external data sources and domain experts. All necessary data are migrated into a unified "PRACA System" (from the supporting databases and expert knowledge sources) eliminating this long-term vulnerability.

4.1.7 Security Issues, Network and System Architecture Recommendations

In the findings, we noted that all the PRACA systems are accessible from the Internet but that they have different security models and LAN implementations to preclude unauthorized system access. As with other aspects of the Project/Element-centric design, the network and security implementations are designed to meet local requirements and are not designed from a Program-wide perspective. As a result, system-to-system communication is very difficult and because of the firewall model (multiple points of authentication from disparate locations) is inconsistent, inflexible and unreliable on a daily basis.

There are conflicting security models and it is not clear why the security is being implemented in specific ways or if it is actually working (i.e., is it really preventing access to unwelcome users?). For example, the firewall security model simply restricts access by computers within the LAN to other computers on that same LAN. Without user authentication anyone on the LAN can access any machine on that LAN. Adding a layer of machine authentication (trusted client) reduces the connection possibilities to specific computers, but still does not control who can access the data (as long as they are on a trusted client). Adding user authentication restricts access to authorized users, but then is often inconsistent and uncoordinated with the firewall and machine authentication. We believe that a secure virtual private network architecture provides a better model for the PRACA system-wide network architecture and can provide the reliable seamless access while enhancing PRACA System security.

<u>Recommendations:</u>

- Identify and establish a security requirements document for the PRACA systems and their data.
- Develop consistent security model for all data, networks, and systems associated with the PRACA System.
  - Eliminate unnecessary data filters and network security bottlenecks.
  - Implement standard system authentication and encryption across systems.
- Standardize on a common network authentication and encryption architecture.
  - Use secure network architecture and create PRACA data links on that network.

<u>Impact:</u>

- Single sign-on for all PRACA related systems.
- Reduced development cost, maintenance overhead, and user management.

- Improved network and system security and access through Center firewalls.
- Simplified data access at all levels.
- Ability to assess security measure adequacy (vis-à-vis requirements) and effectiveness (as measured by security policy violations).

4.1.8 Problem Reporting Work Process Recommendations

Work process assessment is a relatively new technique and its application to the PRACA study was limited to two sites. On-site tracking and interview of the KSC PRACA data collection, and JSC Orbiter problem reporting closure processes were performed during the PRACA work process assessment. The team believes this preliminary assessment of two PRACA centers will validate the utility of a work process study for the SSP and recommends that more detailed studies of additional PRACA sites be performed in the future.

Recommendations:

- Extend the work process assessment to include other PRACA sites, including Marshall Space Flight Center, Palmdale, and the Huntington Beach Problem Analysis Center, and expand the study of JSC and KSC processes to include observational as well as interview data.
  - This expanded analysis of work flow and work process should allow development of models of improved work processes for the use of PRACA at individual sites, and for the transfer and sharing of PRACA information between centers and organizations.
- Re-evaluate the strict hierarchy of problems, based on the tree structure of the Shuttle assembly. This hierarchy makes it difficult to document or describe problems that result from interactions between components in different assemblies or systems.
- Institute training of technicians and engineers in Program-wide PRACA and what kinds of information are being requested and why.
  - Resolve local differences in how different organizations fill out Problem Report fields.
  - Resolve differences between organizations in how they categorize problems.
- Determine why there is so much paper movement, and which of it could better be accomplished electronically.
  - Some of the work being done appears to be more easily and accurately done by a computer than by a human.
  - Evaluate the potential for electronic transfer of all documents and the ability to sign the forms on-line with a password-protected electronic signature.
- Determine if, as suggested, a measure of organizational accountability is “the number of problem reports filed.”
  - If true, this affects the report classification decisions. This would tend to create a work climate where reducing the number of Problem Reports filed, by

tending to identify a nonconformance as a less significant category, has incentive. This would skew the data in the PRACA systems.

Impact:

- Reduced data entry errors
- Improved accountability for data quality, timeliness, and follow-up
- Reduced paper, paper management, and paper trails
- Improve PR turn around time
- Increased visibility into PRACA data yielding better error checking, increased knowledge base, and better-informed and timely decisions.
- Simplified data access at the Program level

5.0 Conclusion

The SSP PRACA System is an essential component to enable increased Shuttle safety and improved assessment of Shuttle readiness for flight. With the emergence of significant growth in the capabilities of Information Technology, the SSP PRACA System is poised to take advantage of the increased capabilities these advances provide. The SSP is motivated to increase the knowledge extraction capability of PRACA by using advanced IT tools for improved ease of access, greater breadth and depth of risk assessments, enhanced data quality and integrity, faster data mining and trending, and progression towards a true Safety and Risk Prognostic capability.

This Study has identified several areas where improvements in technology or implementation can enable a significant SSP PRACA improvement. In addition, the SSP PRACA System enhancement activity is capable of benefiting from other development activities such as Design for Safety (DfS) Program technology insertion, leverage from Aviation Safety Program developments, and other basic information technology enhancements coming from the Intelligent Systems Program.

We believe that an Agency-wide NASA/Industry team in conjunction with the SSP PRACA workforce can bring together the required expertise, knowledge base, and advanced IT capabilities necessary to achieve NASA's Information Management vision for PRACA. In so doing, PRACA will remain a critical and vital system, enabling a reduction in the risk and improvements in safety while supporting the Space Shuttle Program into the next decades.

Appendices

➢ *Acronyms Defined*

ADAM	Advanced Data Acquisition and Management
ARC	Ames Research Center
CAAR	Corrective Action Assistance Request
CAR	Corrective Action Report
CCAR	Contractor Corrective Action Report
CIO	Chief Information Officer
CIL	Critical Items List
COTS	Commercial Off The Shelf
CS	Civil Service
DfS	Design for Safety *(Program)*
DR	Discrepancy Report
ET	*(Space Shuttle)* External Tank
FMEA	Failure Modes and Effects Analysis
GFE	Government-Furnished Equipment
GOTS	Government Off The Shelf
GSE	Ground Support Equipment
IPR	Interim Problem Report
IT	Information Technology
JGPC	JSC GFE PRACA Center
JPC	JSC PRACA Center
JSC	Johnson Space Center
KSC	Kennedy Space Center
LRU	Line Replaceable Unit
MSFC	Marshall Space Flight Center
NCDI	Non Conformance Data Interface (re: TAIR Station)
PAC	Problem Action Center
PCASS	Program Compliance Assurance and Status System
PCR	Process Change Request
PDSS	PRACA Data Support System
PEP	PRACA Enhancement Project
PET	PRACA Evaluation Team
PR	Problem Report
PRACA	Problem Resolution and Corrective Action *(System)*
PRT	Problem Resolution Team
PSA	PRACA System Architecture
RSRM	(*Space Shuttle)* Reusable Solid Rocket Motor
SAIC	Science Applications International Corporation
SAM	System Area Manager
S&MA	Safety and Mission Assurance
SIAT	Shuttle Independent Assessment Team
SFOC	Space Flight Operations Contract
SPDMS	Shuttle PRACA Data Management System
SRB	(*Space Shuttle*) Solid Rocket Booster
SRQ&MA	Safety, Reliability, Quality and Mission Assurance

SRU	Shop Replaceable Unit
SSP	Space Shuttle Program
SSME	Space Shuttle Main Engine
SSRAD	Shuttle Risk and Reliability Database
TAIR	Test Assembly Inspection Record
TCAR	Team Corrective Action Report
TM	Technical Monitor
UI	User Interface
USA	United Space Alliance

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Table 9 - ARC PEP Study Team

➢ Interviews

The PEP Team performed multiple phone and on-site interviews of the following key personnel:

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Richard Shelton, USA

Suzanne Little, USA

Scott Ferguson, SAIC

▪ On-Site Interviews

The following interviews were conducted on-site:

1/5/00 - 1/6/00 - D. Korsmeyer

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Dorothy Rasco

3//8/00 - 3/9/00 - D. Korsmeyer

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4/26/00 – 4/27/00 - D. Korsmeyer, J. Schreiner

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Art Nolting

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