National Aeronautics and
Space Administration
John F. Kennedy Space Center
Kennedy Space Center, FL 32899

March 5, 2004

Reply to Attn of: XA-D

TO: Sam Lewellen

FROM: XA-D/Gregg Buckingham

SUBJECT: KSC Publication

Enclosed is a paper written by a former NASA employee, Frank M. Childers entitled "History of Reliability and Quality Assurance at Kennedy Space Center". Mr. Childers wrote this paper after leaving NASA and has sent it in for possible publication.

I have had it reviewed by three current KSC personnel:

- Mr. Douglas Hendriksen (CC)
- Mr. Bruce Jensen (UB-F)
- Mr. Humberto Garrido (QA)

Subsequent to their review I sent their suggested changes to Mr. Childers and he has returned the manuscript stating he accepted and made the suggested changes. A spot check indicates he did make the recommended changes. The reviewers do think this document would be useful if available to NASA employees in our library. One reviewer said, "Reviewing the document actually helped me understand some of the KSC Safety and Mission Assurance history, especially at a time where organizational changes are imminent". As far as publication, the consensus was the document should be published (copied) in house as a KSC Historical Report rather than published through GPO.

Prior to placing the report in the KSC Library, I am submitting it to you through the DAA process. If you have any questions, I can be reached at 867-8777.

Dr. Gregg A. Buckingham
KSC University Programs

Enclosures

KSC Historical Report No. 20

(KHR-20)

February 2004

History of Reliability and Quality Assurance At Kennedy Space Center

Cover is in Graphics

Written by
Frank M. Childers
Aerospace Engineer (Retired)

CONTENTS

FOREWORD

History of Reliability and Quality Assurance at Kennedy Space Center

Space exploration has been the dream of mankind since he looked at the heavens. Understanding the stars and planets and our relationship to the entire universe continues to be a challenge even with significant advancements in rocket technology.

This Kennedy Hisorical Document (KHD) provides a unique historical perspective of the organizational and functional responsibilities for the manned and un-manned programs at Kennedy Space Center, Florida.

As systems become more complex and hazardous, the attention to detailed planning and execution continues to be a challenge. The need for a robust reliability and quality assurance program will always be a necessity to ensure mission success. As new space missions are defined and technology allows for continued access to space, these programs cannot be compromised.

The organizational structure that has provided the reliability and quality assurance functions for both the manned and unmanned programs has seen many changes since the first group came to Florida in the 1950's. The roles of government and contractor personnel have changed with each program and organizational alignment has changed based on that responsibility. The organizational alignment of the personnel performing these functions must ensure independent assessment of the processes.

The commitment to excellence by the dedicated professionals, who ensure the safety, quality and reliability of each mission, is an attribute to all who have worked so hard throughout this history of launches from Cape Canaveral and NASA launch sites.

Frank Childers has taken 50 years of history and condensed it into an interesting reflection of his commitment to reliability and quality assurance and his passion for the space program.

J.Chris Fairey, Director, Safety and Mission Assurance
NASA, Kennedy Space Center (retired)

DEDICATION

This volume is dedicated to the past and present Kennedy Space Center Reliability and Quality Assurance managers who gave their dedicated support over the years of our nation's manned space program, and also to the past and present members of the NASA Alumni League, Florida Chapter, for their encouragement and support.

The following list includes the leaders of the KSC Reliability Coordination Office Chiefs and the KSC Quality Assurance Chiefs in order of service:

<u>KSC Reliability Coordination Office</u>

R.L. Body, 1962 - 1967
William Rock, 1967 till end of Apollo Program

<u>KSC Quality Assurance Office Chiefs</u>

R.L. Gramer, 1960 -1965
R.A. McDaris, 1965 - 1977
J.R. Atkins, 1977 - 1980
W.H. Rock, January, 1980 - July, 1980 (Acting)
L.C. Parker, July, 1980 - November, 1985
M.L. Jones, November, 1985 - September, 1987
R.E. Reyes, September, 1987 -1995
J.C. Fairey, 1995 - 1998
A.D. Montgomery, 1998 - 1999
C.A. Staubus, ELV Flight Assurance Office, 2000 - 2003
B.L. Jansen, ISS/Payload Processing Division, 1999-2003
R.R. Hammond, Shuttle Processing, 2000 - 2003
R.R. Gillett, Safety and Mission Assurance Project Assessment Office, 2000 - 2003

Plus the numerous R&QA Surveillance Office Chiefs of the KSC decentralized R&QA period, such as Dan Collins and John Fike of Information Systems Directorate, Otto Fedor of Design Engineering, Joe Bobik of Spacecraft Operations, Doug Black of Space Task Group, Don Oswald of Launch Vehicle Operations, and others.

ACKNOWLEDGEMENTS

I give sincere thanks for Mr. J. Chris Fairey, former Director, Safety and Mission Assurance for coordinating this whole document through a review process at Kennedy Space Center, and for crafting the fine FOREWORD for this history.

The following participants in this KSC R&QA History are acknowledged with gratitude for their support in providing vital information and for reviewing/commenting on the two drafts that were issued. Without such a devoted effort, the compilation of this Reliability and Quality Assurance History could not have been completed.

Suzie Byrd, KSC Library
Dave Dibler, KSC
J. Chris Fairey, KSC (retired)
Bruce Jansen, KSC
James Joyner (Retired)
Elaine Liston, KSC Archivist
Donna Lozaw, KSC
Ann Montgomery, KSC (Retired)
JoAnn H. Morgan, KSC (Retired)
Glenn Otto (Retired)
Norm Perry (Retired)
Ernie Reyes (Retired)
Calvin Staubus, KSC
Gene Thomas (retired)

The above reviewers offered many valuable comments, organization charts, and other important information through the printed word, through conversation, and by providing NASA and contractor R&QA documents contributing to the overall goal of this challenging task. Plus I give credit to my wife, Lois E. Childers, for her editing efforts.

INTRODUCTION AND AUTHOR'S COMMENTS

For centuries, mankind has gazed longingly at the heavens, wishing to be closer to angels than to be a species doomed to cling, heavy and gravity-footed, to the earth. Poets, dreamers, and scientists, enviously watching the freedom of birds, all yearned and planned for the day when humans would join the seemingly-impossible celestial flight.

In 1903 the Wright brothers proved that where man's mind could go, the body could follow. Following World War II, the interest in actual space-flight grew, and a talented team was assembled to boost/launch mankind into the realm we call "space" today. Some of the team were German rocket scientists and engineers who chose to join American forces in its missile and space program after World War II.

In order to boost Americans into space, special launch vehicles and space-craft had to be developed, tested and flown. A talented team of 37 rocket scientists, engineers, technicians and Army Ballistic Missile Agency (ABMA) personnel from Redstone Arsenal, under the direction of Dr. Kurt Debus, pioneered the way for accomplishing the successful testing and launching of many Army missile flights and the two early manned flights using the small Redstone Rocket going toward the goal of space travel we celebrate today. The ABMA Missile Firing Laboratory's first Redstone missile launch took place from Cape Canaveral, Florida on August 20, 1953.

The work-ethic of this initial team was deemed all the Safety, Reliability, and Quality Assurance needed in those early days of rocket launchings. A formal Reliability and Quality Assurance program was not adopted until the Apollo Program began to take shape in the 1960's.

The Space Test Group joined the Debus team in January,1965, and the Vanguard team joined in October,1965, forming the Kennedy Space Center (KSC). The Launch Operations Center headed by Dr. Kurt Debus was officially formed July 1, 1962, and renamed to honor President Kennedy in November, 1963. These groups made history as they continued their successful work with satellites and with manned space flights under different organizations.

One major goal of these groups sailed majestically through the skies - the moon. Throughout history, the moon had been the symbol of human yearning, celebrated in mythology, legend, song and poem.

At Rice University on September 12, 1961, President Kennedy set the mood for the United States to visit the Moon, when he said:

> " We set sail on this new sea because there is knowledge to be gained, and new rights to be won, and they must be won and used for the progress of all people. For space science, like nuclear science and all technology, has no conscious of its own. Whether it will become a force for good or ill depends on man, and only if the United States occupies a position of preeminence can we help decide whether this new ocean will be a sea of peace or a new, terrifying theater of war."

Historically, in 1969, the United States became the first to set foot upon the moon, claiming this ancient mystic symbol "in peace for all mankind." The story of how the lead nation of the free world accomplished this challenge is a story of dreamers, doers, and the dedication of launch teams beyond any worldly compensation.

America soared to glory, experienced heartbreak, and daily, kept alive the commitment to explore new worlds beyond the stars. This history of Reliability and Quality Assurance, this history of man's best efforts toward a job well done, is dedicated to all those who lost their lives reaching for the stars - and to those who will continue to carry the flame of human curiosity, dreams, and intelligence to galaxies yet unknown.

In January 1972, I realized that my files contained a great deal of vital historical data on the beginnings of the Reliability and Quality Assurance (R&QA) Program at the John F. Kennedy Space Center (KSC). In anticipation of retiring in a few years, I began to research my files and talk to other Quality Engineers about writing a summary history of R&QA at KSC. I was encouraged by my manager, Mr. John Fike. So in my spare time, I began the task. I completed the brief history in January 1974, and had copies printed by the KSC Reproduction Section for distribution to many of the KSC R&QA employees and managers right away.

Early reliability and quality assurance efforts at the Army Ballistic Missile Agency (ABMA) are important in this study, because personnel from ABMA made up the core organization around which the Kennedy Space Center was organized. Their contribution is recorded within Chapter 1 of this document, and includes the small-team work ethic and the attention to detail required by all launch team members during checkout and launch of the early Redstone and Jupiter missiles. Dr. Kurt Debus' Memoir Paper, "FROM A-4 TO EXPLORER 1," is important in describing the early interest in R&QA by ABMA managers. The story begins on page 1 of Chapter 1.

This NASA document is an attempt to up-date that brief history. The main thrust of the effort will be in the area of human space flight at Kennedy Space Center. The advent of the Mercury Program was the driving force in establishing a more classical reliability and quality assurance effort. The fact that human beings would be propelled into space was concern enough for Congress to fund such a program.

I approached the present Director of Kennedy Space Center, Roy Bridges, at the 1999 annual KSC Christmas Coffee about the idea, and he introduced me to his Director of Reliability and Quality Assurance (later Director of Safety and Mission Assurance), Mr. Chris Fairey, who immediately gave me an appointment at his office to discuss the project. Mr. Fairey was receptive to the idea and promised support and a review effort after the document was completed. Right away I contacted other important Apollo R&QA participants who promised support and contribution to this historical document. I proposed to Mr. Fairey that this effort should be issued as a NASA Historical document and hoped to get an official NASA document number and have it printed by NASA or the Government Printing Office.

At the beginning of the manned flight programs in the early 1960's, KSC and other NASA organizations earnestly began to organize a Reliability and Quality Assurance (R&QA) program, because the goal of placing humans into space would require very reliable ground support equipment as well as highly reliable launch vehicles and spacecraft. Admittedly, the problem of building a reliable product to perform a specific function is ancient. However, as products had become more and more complex, the problem of building a reliable product had become more difficult. In addition, during

World War II, many types of equipment were developed which had to work under wide environmental conditions for extended periods of time if the military mission was to be accomplished. The addition of a time dimension to already difficult problems, and the increasing complexity of equipment, posed more design and development difficulties to our military manufacturers.

During that war, great strides were made in the development of quality control techniques. However, most of the early applications of quality control concentrated on manufacturing and inspection phases.

Subsequently, the Atomic Age and Space Age hardware requirements introduced even more stringent controls on the manufacturing and inspection phases, and expanded requirements into the installation, operations and maintenance phases.

Aeronautics technology was ushered in on December 8, 1903, by Samuel Pierpont Langley with his manned glider fitted with a small internal combustion engine which failed on launch from its Potomac River houseboat catapult, and by the Wright Brothers of Dayton, Ohio, nine days later, December 17th. 1903, at Kitty Hawk, North Carolina.

In 1909, the Army purchased its first military airplane. In 1915, the U. S. Congress established a National Advisory Committee for Aeronautics (NACA), after Europe had outstripped the U. S. in aeronautics leadership.

During the first World War, NACA aided significantly in the formulation of national policy on such critical problems as the cross-licensing of patents and aircraft production.

In the 20's and 30's, aeronautical science and aviation technology continued to advance. During these decades, NACA brought the United States to worldwide leadership in aeronautical science. NACA worked closely with the Army and Navy, the National Bureau of Standards, and with the young and struggling aircraft industry to enlarge the theory, technology of flight, structural materials, and power plants. Together with these advancements was the growing field of Quality

Assurance and Quality Control.

During the World War II period, the concept of mass production was exploited. Experience proved that American industry was able to respond to military requirements. Quality Control was essential to obtain reliable products for the men on the field of battle. Most of the workers were closely associated with the war effort through their own family members in the fighting ranks which resulted in a measure of motivation for quality products. The government, through decentralized military agencies or departments, upgraded and otherwise caused Military Specifications to be written for every product required. Quality assurance provisions were either included in specifications or were written around the specifications, as required.

Military Specifications and Standards played a most important role in assuring that the manufacturer had the correct guidelines for building a product, and that quality assurance had correct acceptance criteria for the product. Federal Specs and Standards followed the same general format and were for the same purpose as MIL-Specs and Standards. MIL Handbooks were another means used in establishing guidelines in many areas of quality assurance.

One example of how these documents treated Quality Assurance is taken from ORDM 4-12, 'Quality Assurance Technical Procedure,' as follows:

> "The resources and efforts of the Ordnance Corps are devoted to furnishing the Armed Forces with effective and reliable material which will function as intended when and where required.
>
> The term "Quality" can, and frequently does, mean different things to different people. From the standpoint of the Ordnance Corps, total quality with respect to an item is synonymous with complete attainment of the design objective, providing, of course, that those objectives accurately reflect the user requirements and are technically and economically feasible.
>
> The role of the Ordnance Inspector is rather unique. While his responsibilities may be numerous and varied, his authority is limited. His primary function is to assure complete compliance with the requirements of the contract or work order. In this, he must maintain a singleness of purpose. His insistence upon rigid conformance to all applicable requirements is essential to assuring effective ordnance material. Even in those instances where drawings and specifications do not accurately reflect the design objectives, strict compliance with the requirements will assist in identifying such deficiencies. Only by strict

enforcement of the contract or work order requirements can the adequacy and completeness of those requirements be ascertained. Pressures to meet delivery schedules must not influence the inspector to accept something less than specified in the contract or work order. Furthermore, it is not within his authority to exercise judgment as to the adequacy or equivalency of substitute requirements. This role must be reserved for the responsible engineering agency. From the foregoing, it is apparent that the inspector must be an individual of high integrity and must be unswervingly resolute in the performance of his assigned tasks.

Contractor and ordnance production support activities are responsible for controlling product quality for, and offering to the Ordnance Corps for acceptance, only those items or lots of items which have been determined by them to conform to contractual requirements.

The Ordnance Corps is responsible for determining that contractual or project requirements have been complied with before acceptance of the product." (1)

These excerpts from Ordnance Corps ORDM 4-12 give us some insight into what the Quality Inspector's role was in the Ordnance Corps, and still remains basically true for a Quality Inspector today in assuring quality products for space program applications.

Chapter 1.

HISTORY OF QUALITY ASSURANCE AT THE ABMA MISSILE FIRING LAB

In the early 1950's, the Army Ballistic Missile Agency (ABMA) Laboratories at Huntsville Alabama were in the process of static testing the Redstone ballistic missile as final design specifications were being developed for the flight hardware and attendant ground support equipment. Much attention was given to good documentation and configuration control. Each design organization was held responsible for all quality, suitability, reliability, etc., for each static test. Major changes were closely coordinated with interfacing elements to preclude operational problems. Committees, working groups, and task groups for specific systems, maintained sufficiently tight management control of both flight and ground support hardware.

Quality Assurance as a formal program was not required, but the following excerpt from Dr. Kurt Debus' Memoir Paper, "From A-4 to Explorer 1" describes the reliability goals of the Redstone and Jupiter missiles very well. One can see how the role of reliability and quality assurance was becoming more important as the Army missile vehicles were being considered for ventures into space:

> "Redstone's development program commenced May 1,1951, and continued seven and one-half years, terminating with the last research and development launch, November 5, 1958. Between those dates, many changes in the hardware took place involving tracking and telemetry systems, fabrication, assembly and propulsion. The engine contractor supplied seven different versions of the power plant and introduced such improvements as a liquid oxygen pump inducer to prevent cavitation, full flow start, gage pressure thrust controller, and absolute pressure thrust controller. Early Redstone employed an autopilot control system. Components of the inertial guidance system were carried as passengers which expedited the development of the complete system tested for the first time on Redstone No. 11, September 21, 1955. Industry supplied fuselages, guidance components, and many other items. Chrysler Corporation was selected as prime contractor and fabricated Redstone missiles in a Government-owned plant in Michigan. Missiles 1 through 12, and 18 through 29 were built by the Guided Missile Center while Chrysler produced Nrs. 13 through 17, and all of the

missiles from No. 30 on. Thirty-seven were launched in the research and development phase but only 12 of these were flown exclusively in support of the Redstone program.The others contributed to the follow-on Jupiter missile which will be discussed later. In all, 62 Redstone missiles including the tactical version were produced before the program ended in 1960 as the lighter and more mobile Pershing missile succeeded Redstone.

Our relations with industry were both challenging and, in the end, highly satisfactory. We insisted upon quality and reliability standards that were unprecedented, and specified tolerances and precision that seemed almost impossible. But there were healthy curiosity and excitement about this new field. Chrysler put engineers in the laboratories at Redstone Arsenal to acquire at first hand the techniques of fabrication and assembly. Drawings of dies, tools, jigs and fixtures were turned over to the contractor to assist setting up his production line.

There was good reason for our seemingly arbitrary concern with reliability. From painful experience during the Peenemuende development, we clearly understood the direct relationship between high reliability and high accuracy in the guided missile. The U.S. Army wanted better than 90 percent reliability in Redstone and specified the maximum circular probable error at the target. In February 1952, I presented Center management a proposal to elevate reliability functions to top level and install the program in every organizational element concerned with the Redstone development. The proposal derived from analyzing guided missile systems and any part could be classified as "parallel" or "series" in operation. Failure of a "parallel" part would probably not result in failure of the system since its function could be taken over by another part.

Failure of a "series" part would ultimately result in total failure. For example, relay contacts, soldering spots, tubes or most structural parts would, if they failed in flight, cause malfunction or failure of the vehicle. The fact was that overall reliability of the whole system equaled the product of the individual reliabilities of all series components.

1. A guided missile having 100 series components, each component having an average reliability of 99 percent, will probably succeed in only 36.5 percent of firings.

2. If there are 300 series components of the same average reliability, the chances for success are reduced to 5 percent. While this appraisal stirred up considerable argument, management created a reliability office and the program was installed within the center and contractor organizations. These initial beginnings of reliability considerations have evolved into today's management systems.

During the White Sands period, the prelaunch and launch functions were performed by a team made up of cadres from several different elements of the project. No one organization had the overall responsibility for check- out, assembly, testing and launch operations. Looking ahead to the demands of the Redstone and subsequent programs, I advised Dr. von Braun that in the long run we would require an integrated group responsible for the launch phase. As a consequence, I established the Experimental Missile Firing Laboratory.

Having taken direction of the Laboratory, I drove to Florida in early 1952 with my deputy, Dr. Hans Gruene, the first two employees of today's Kennedy Space Center, to look over the Joint Long Range Proving Ground which had been established in 1949 with headquarters at Patrick Air Force Base and launch sites at Cape Canaveral, Florida, 24 kilometers (15 miles) north on the Atlantic Coast."

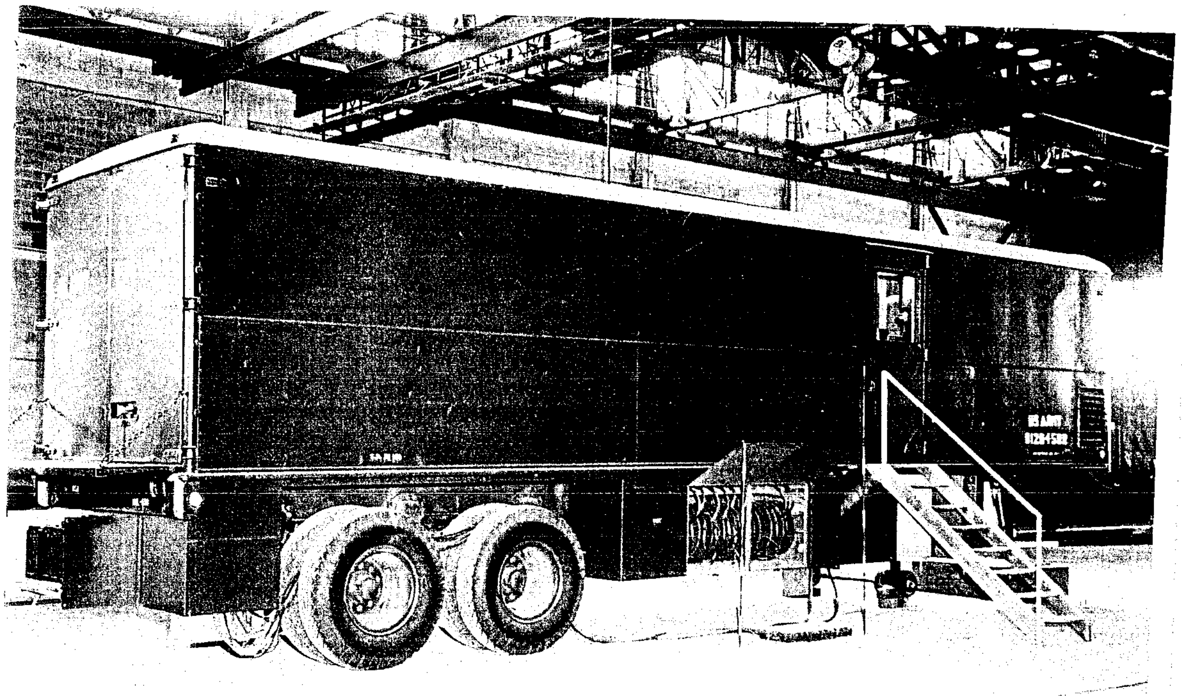
(2)

ABMA management and senior members of the launch team had very good qualifications to successfully prepare and launch the early missiles since they had participated in preparation and launch of sixty-six German V-2 rockets at White Sands Proving Grounds in New Mexico and of two modified V2's at Cape Canaveral. Launch checkout and operational philosophy developed and used for those launches were put into use on the early Redstone launches. Operational philosophy dictated that each organizational element of the launch team be responsible for its own equipment readiness.

Launch preparations consisted of detailed checkout of all flight systems and ground support equipment, and of coordinated functional tests with all systems running. Such tests were refined during successive launches until eventually flights were actually simulated from takeoff to impact on target.

Detailed checkout of flight hardware involved the use of mobile measuring units equipped to simulate flight conditions for on-board sensors. Much care was taken to establish that all measurements were within the calibration limits provided by design agencies. This was provided by permanent records made of specified calibration points. Calibration records of the actual recorders and telemetry systems used were also a requirement in the process of establishing confidence in actual flight data.

The following photographs of the Electronic Measuring Trailer, supporting one of the early Redstone launches, show some of the measurement team at work performing quality checks on vehicle measurements and ground voltage measurements, as well as all the vehicle pressure measurements involved. Each vehicle measuring device was energized with a calibrated value of voltage, resistance, or pressure in order to assure that each vehicle signal-conditioning device achieved the proper output back to the trailer through attached ground cables or through the telemetry system during simulated tests.



Missile Measurement Van For Redstone, Mercury-Redstone, and Jupiter missile launches.

Inside View of Measurement Trailer During Missile Measurements Checkout and Verification

(Left to Right: Grady Williams, Wally Wallicer, Carl Jones, Fred Conneway, Frank Childers, Alex Welhan, Robert Funkhouser)

From the very beginning of the Army Missile Program, much emphasis was placed on accurately calibrated measuring and test equipment. The small Calibrations and Standards Laboratory set up at Cape Canaveral provided the necessary calibration and traceability to the National Bureau of Standards for all measuring and test equipment used in launch preparations.

The electrical network and propulsion systems of the Redstone missile were thoroughly checked out by highly-trained engineers and technicians who had received most of their experience during the static testing phase of development. Such experience continuity proved invaluable in assuring successful launch missions. During the five-year span of the Army testing, thirty-eight Redstones were fired to test the structure, engine performance, guidance and control, and tracking and telemetric systems. This work was done entirely under the aegis of research and development (R&D).

Appendix No.1 documents the type of measurements which had to be tested, measured and calibrated before each Redstone launch. As the Redstone launches progressed, the measurement list became longer and more complex depending upon advancements made in measurement technology and in the telemetric and tracking systems. The pages document the measurement program for Redstone (RS-1), which we launched on August 20, 1953.

At that time in technological R&D (Research and Development) projects, quality assurance was not a necessary discipline outside engineering and operational functions. The words, quality assurance, or reliability, were not a part of operational vocabulary, but rather they were highly implied in each team member's work area. This high sense of the importance of job function was initiated at static testing and was maintained throughout prelaunch preparation and launch of these first ballistic missiles by the Army's Missile Firing Laboratory at Cape Canaveral. Thus, the quality of ground control and missile data was assured by a small-team work-ethic.

The Army missile team at Redstone Arsenal held to the time-honored Army-arsenal concept whereby research and development and some fabrication took place in Government facilities. The Army Ballistic Missile (ABMA) Firing Lab at the Cape had complete responsibility for the quality of the missile firing effort. The receiving, erection, checkout and launch activities were performed by the small Army-civilian team with knowledge due to several of the Missile Firing Lab team having gained experience with the V-2 rocket launches at White Sands, New Mexico. That knowledge was useful both at Huntsville and at the Cape when new employees had to be trained in their support functions. The many successful Redstone launches qualified the Missile Firing Lab to be ready for the launching of Explorer 1 on January 31, 1958, the free world's first satellite, Then later, the first American astronauts of the Mercury Program were placed into space: Alan Shepard on May 5, 1961, and Gus

Grissom on July 21, 1961.

Some failures were experienced during the five-year Redstone R&D Program and the Jupiter IRBM Program. Some were due to inevitable human error and some were due to mechanical and/or electrical failures. Fortunately, enough measurement parameters were telemetered to the ground which allowed for thorough analysis and problem evaluation. Failure data was faithfully fed back to design agencies for corrective action. The integrity and conscientiousness of dedicated individual team members were the secret of the R&D mission successes, rather than the rigid quality assurance methods we know and use today. Much can be said for the team concept if the team remains small and communicative. As the team grew in numbers and as functions were contracted out to aerospace contractors, the formal quality assurance concept became more important.

The advent of the Chrysler Corporation into the design and fabrication phases of operational Redstone and Jupiter Missiles at Redstone Arsenal brought on the first formal quality and reliability programs. That fledgling quality assurance program grew into an honored position in the Army Ballistic Missile Agency and propagated itself into the Pershing Missile, manufactured and launched by the Martin Marietta Corporation. The launch team's role in this instance was to monitor, suggest, and interface with launch team counterparts, until the Army and contractor teams were thoroughly trained and experienced in the launch phase of development. The quality assurance term, "zero defects," was first heard during the Pershing Project, and that term began a whole new way to look at total quality assurance in both government and industry.

At this point in the study of Reliability and Quality Assurance (R&QA), it is important that terms, reliability and quality assurance be defined.

RELIABILITY: "Reliability is the probability that a system, subsystem, component or part will perform its required function under defined conditions at a designated time and for a specified operating period with a stated accuracy. QUALITY ASSURANCE: "Quality Assurance is defined as: "A planned and systematic pattern of actions necessary to provide adequate confidence that the end items will perform satisfactorily in actual operation."

CHAPTER 2

BEGINNINGS OF R&QA AT KENNEDY SPACE CENTER

R&QA history at the Kennedy Space Center began in the spring of 1962 when a QUALITY ASSURANCE OFFICE and a RELIABILITY OFFICE were established as staff functions to Dr. Kurt Debus, Director of the Launch Operations Directorate (LOD). The LOD was a part of the Marshall Space Flight Center (MSFC) at that time. Subsequent reorganization action approved by NASA, established the LOD as a separate and independent NASA Launch Operations Center (LOC). The LOC officially opened July 1, 1962. And then on November 29, 1963, it was renamed the John F. Kennedy Space Center in memory of President Kennedy.

The Mercury Project QA team was already established in Hangar "S" at the Cape and at St. Louis accepting McDonnell work on the capsules prior to 1961. The team was known as the Space Task Group under the management of Mr. G.M. Preston. Preston's team was later called the Manned Spacecraft Center (MSC), Florida Operations.

During the time of design and testing of the Mercury and Gemini spacecraft, Florida Operations QA personnel were assigned to MSC-White Sands Operations where the Apollo launch escape system and the earth landing systems were man-rated and certified to support the lunar landing program. MSC QA personnel from Florida were also assigned to El Centro, California to perform QA functions on all manned capsule parachutes.

Prior to establishment of the Quality Assurance Office at the Cape, the Launch Operations Directorate relied on MSFC for support, including quality assurance, reliability, purchasing, and contractor surveillance. Early in 1962, the LOD set up its own purchasing and contracting office. Establishment of this office required local quality assurance support in procurement requests. The first instance of quality support was in the contract for modifying Launch Complex 36 for the Atlas/Centaur Program. The policies and directives of General Dynamics were reviewed for compliance with NASA R&QA requirements. The Army Corps of Engineers survailed and monitored the build-up of this and other launch facilities for the LOD, performing all configuration control and inspection functions during the over-all construction phases. The Corps support continued through the completion of the Apollo Saturn V facilities at the Merritt Island Launch Area (MILA).

NOTE:

Since the LOD was not staffed by quality assurance personnel at the time of the turn-over of Corps work to KSC, Mr. Norm Perry of Marshall Space Flight Center was detailed to inspect and do the final buy-off of the Army Corps of Engineer work on complex 34. He had interesting stories on this task. The work was finished and an official quality assurance acceptance was performed in this manner.

A Reliability Office was created in 1962, headed, initially by Mr. Robert L. Body and two young engineers, James Joyner and John Copeland, and a secretary, Marge Holt. Their emphasis was placed on failure reports and unsatisfactory condition reports as well as corrective action and failure mode and effect analyses of ground support equipment. They were housed in a trailer at Hangar D.

Two months after the LOC was established in July 1962, a Quality Assurance Office was established as a staff function to the Center Director, and provided all quality assurance support to the Center Procurement Division.

The History of Apollo Launch Facilities and Operations called MOONPORT, NASA SP-4204 was published in 1978. We find reference to the establishment of the first KSC Quality Assurance Office on p.139:

> "....Mr. Russell Gramer, head of the Quality Assurance Office, established operations in half a trailer at Cape Canaveral with seven employees. When the staff grew to 13 times that size, his force had to expand into other quarters. The Quality Assurance people worked in such widely scattered places as an old restaurant on the North Cape Road, a former Baptist church on the Titusville Road, a residence on Roberts Road, and numerous trailers." (3)

Mr. Gramer hired Mr. Norm Perry of Marshall to set up an inspection school at the old restaurant mentioned above. The author remembers visiting the soldering school at that location early in the R&QA training at KSC.

The first instance of Quality Assurance support provided by the new office was during the purchase of the twenty-four foot telemetry antenna for the Electronic Engineering, Measuring, and Tracking Branch. The QA Office Chief remembered the congenial conference with the system engineer and his acceptance of the quality requirements for the contract. Ready acceptance of quality requirements was not always the rule at the Center. LOC History showed that reliability and quality assurance made a continuous uphill struggle for acceptance. Both Design and Operations thought of R&QA as an intrusion into their areas of responsibility. As time passed, higher management and the untiring efforts of the R&QA Offices began to break the open resistance and to gain a degree of acceptance. We find reference to this on pages 45-46 of MOONPORT:

> "As one veteran recalled, "In the 1950's we looked at equipment when it came down here as not trusting a single thing in it. We were going to check everything from one end to the other." Consequently, LOD's checkout was precise and exhaustive, "a laboratory type check on the pad." Basic operating procedures were established and followed closely. Debus detailed some of these procedures in a letter to NASA Headquarters shortly after the first Saturn launch. LOD employed a test sequence that proceeded from components, through subsystems and systems, to overall tests. . . . The technical checkout of the various Saturn systems fell to LOD test engineers. Debus considered these engineers "the backbone of LOD test activities;" they carried full responsibility for preparing a launch vehicle to the point of launch readiness, and merited equal status with . . . engineers in design, development, and assembly operations. While an error made in the design or development phase could be detected by a test engineer, a mistake by an LOD system engineer would inevitably lead to mission failure."
>
> Conceding that launch site tests were part of a continuous program to assure reliability and quality, Debus stressed the test engineer's need for autonomy. "Since the system engineer carries the full responsibility for the flight-readiness of his assigned system, this responsibility should not be attenuated by assigning a separate inspection or quality assurance team to check on the system engineer for compliance to test procedures and test performance. . . A systems engineer had to be kept informed continuously of the status of his assigned system and all occurrences during the test period." (4)

During the preparation of Pad 34 to launch the Saturn 1B's, the fledgling reliability and quality assurance offices felt this resistance very much. No one felt at home in the blockhouse or on the pad when it was necessary to perform a quality action or when it was proper to interface with a system engineer who was working under the above underlined directions."

KSC R&QA efforts came from the highly qualified operations and checkout team developed during the ABMA days here at the Cape, and from the well experienced QA team from the Manned Spacecraft Center, Florida Operations, which was transferred to the Debus team January 1, 1965. The MSC team had functioned well for all the Saturn 1, 1B, 1C launches from Pads 34 and 37. R&QA inspection efforts consisted of checking and double checking of practices to assure that measurements and parameters that controlled the launch equipment/system's performed as intended.

When KSC had absorbed Houston's Florida Operations team, KSC was supposed to have assumed direction of the spacecraft contractors at the Cape. The North American and Grumman teams at KSC, however, had continued to look to their home offices, and indirectly to Houston, for guidance. This old method of operation ended in the aftermath of the LC-34 tragedy on January 27, 1967. With the support of NASA Headquarters, KSC took firm control of all spacecraft activities. This gave more strength to quality assurance surveillance efforts and pad-safety at Pads 34 and 37, and later at LC-39 pads.

Early in the Merritt Island Launch Area (MILA) operations build-up, some KSC procurements slipped by without R&QA requirements in the procurement requests. One particular procurement remembered by the writer was Contract NAS10-1909, dated October 27, 1964. The contract was let to "Monitor Systems, Inc.," of Fort Washington, Pennsylvania, for a digital telemetry system called "Data Core." In that instance, NASA Headquarters' review of the procurement revealed that no R&QA requirements had been incorporated. KSC was immediately notified of this and was requested to visit the contractor facility to review their R&QA standards for possible acceptance for the KSC contract.

Mr. Peter Mindermann, Chief of the Telemetry and Tracking Department, along with a NASA Reliability Engineer, Frank Childers, and Norm Perry (KSC QA), were given travel orders to fly to Fort Washington to resolve the problem. Subsequently, Chapter 7 of Monitor Systems Proposal Number 464202, which outlined their R&QA Program, was invoked in the contract.

Through use of the contractor R&QA standards, in conjunction with the KSC Quality Surveillance Technical Representative (QSTR), Norm Perry's visits, an acceptable system was delivered. Norm Perry, remained as the QSTR after award of contract, where he certified Monitor Systems' special processes for the KSC contract.

The trouble encountered in this procurement gave impetus to the Center's responsibility for incorporating proper R&QA provisions into contracts in accordance with NASA Procurement Regulations, NPC-400 issued in January 1964. NPC-400 was issued as a separate publication and incorporated and superseded all the procurement material published in Chapter 18 of the NASA Management Manual issued prior to September 18, 1963. Extensive editorial changes were made and new material such as Sub-Part 50, "Integration of Quality Requirements in NASA Procurements" and Subpart 51, "Integration of Reliability Requirements into NASA Procurements" were added.

This particular procurement forced the Center procurement and R&QA personnel to get involved in the cooperative effort of invoking appropriate R&QA requirements into contracts for launch critical equipment.

NASA Quality Publications NPC 200-2, "Quality Program Provisions for Space System Contractor's" and NPC 200-3, "Inspection System Provisions For Suppliers of Space Materials, Parts, Components, and Services," issued in April 1962 along with NPC 250-1, "Reliability Program Provisions for Space System Contractors," issued in July, 1963 came into use at that time as implementing documents. Subsequently the Center issued KMI 5310. 2, "Incorporation of Reliability and Quality Assurance Requirements in KSC Procurements," to require such implementation. Mr. Norm Perry, of KSC QA, remembered that he was on the Review Board for such documents.

After President Kennedy announced Apollo Program in 1962, the project blossomed into a national buildup of contractors located all over the United States. The geographical distribution of NASA contractors/vendors placed too much demand on the new NASA Center R&QA surveillance effort for adequate coverage. Whereupon another NASA quality publication, NPC 200-1, "Quality Assurance Provisions for Inspection Agencies" issued in

April, 1962, came into use as the Center began to delegate quality surveillance to other government inspection agencies located in the vendor areas or in their plants. This method proved to be successful, in that reliable equipment with adequate historical documentation was delivered to Center users for the first time.

Needless to say, all this activity in reliability spurred Center R&QA training activities. Marshall Space Flight Center (MSFC) with some degree of history in R&QA concepts, was called upon to present courses in quality assurance for engineers and technicians who had been transferred into quality assurance positions early in the Apollo Program.

The following classes were given in the on-going education effort to qualify all Quality and Reliability Engineers in the Apollo, Skylab, and Apollo-Soyuz Programs:

Report Writing, Oct. 1963.
Reliability Engineering Seminar For Managers (GE. ASD), Nov. 1965.
NASA Quality Requirements, Dec. 1967.
Contractor Performance Evaluation Seminar, Mar. 1969
Executive Seminar For Scientists and Engineers, Jan. 1970.
Basic Management Techniques I and II,1970.
U.S. Army Material Corrosion Control Course, March, 1974.
Several other classes were given as needed in a particular work area.

These courses along with membership in the Florida Chapter of the American Society of Quality Control (ASQC) was instrumental in educating the participating Reliability Engineers and Quality Engineers at KSC. Several of the engineers were given ASQC certification in their fields after proper qualification through education and experience. KSC policy allowed administrative leave for attending the Florida Chapter/ASQC meetings. During this period (1963-1965), Spacecraft Operations and the KSC Launch Operations and Installation Support Directorates had organized Quality Assurance Offices. The Center Director for Quality Assurance was established in 1965. The Director, Quality Assurance, operated as a staff function to the Center Director. The Director of QA was charged with developing and establishing policy and developing methods of surveying and auditing the Center QA Program.

The Spacecraft Operations Directorate's Quality Surveillance Division had been functional from the very beginning of the Mercury Project in 1961 at KSC.

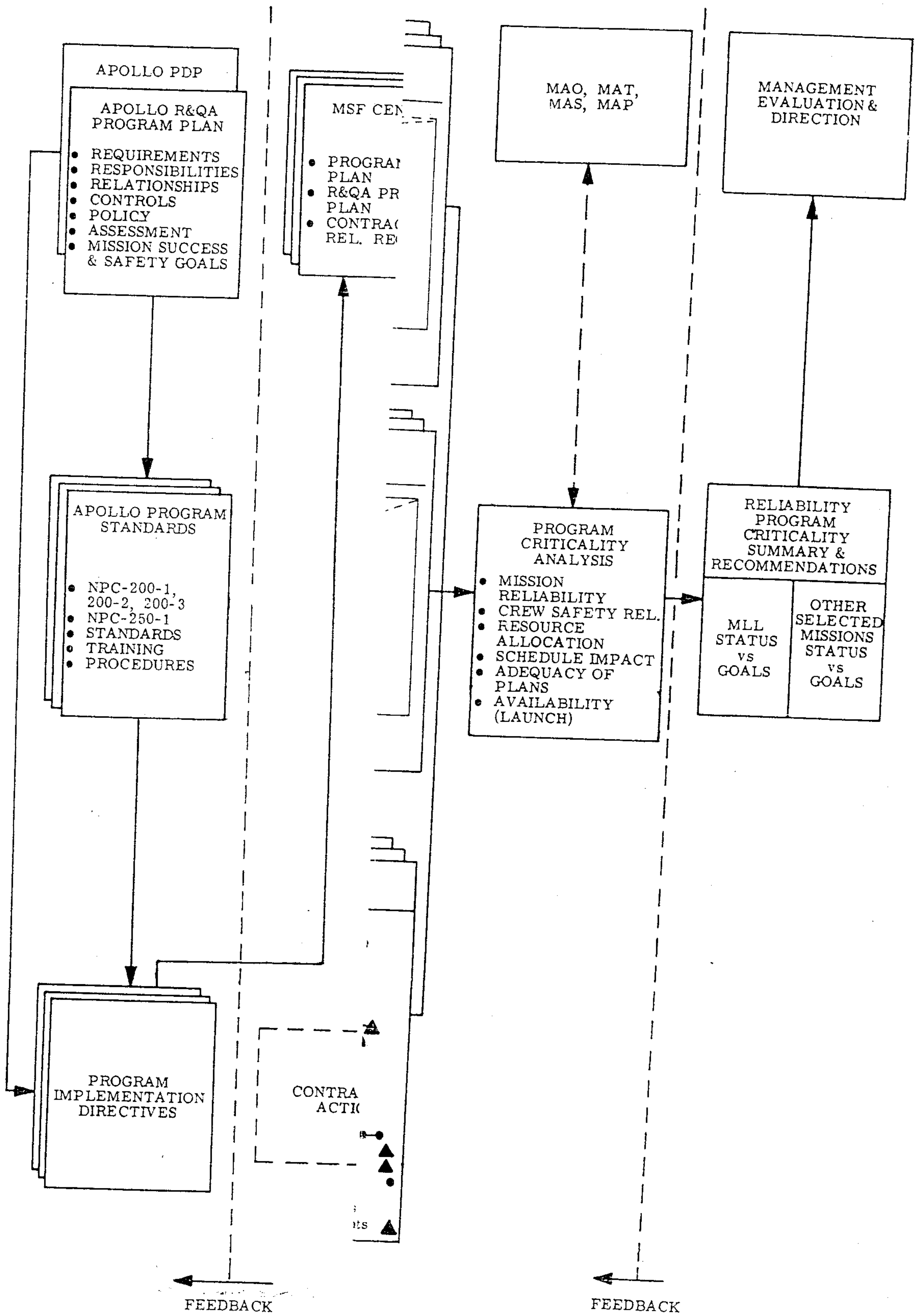
Early in the Apollo Program, NASA Headquarters was busy trying to get each Center to accept help from the NASw-410 contract with General Electric at Daytona Beach, Florida. Mr. Pat Mongillo ,of the Contracts Office, was tasked to call a meeting for October 21, 1964, at Kennedy Space Center. Historical data on this meeting are found in Appendix 2.

The purpose of the meeting was to cover the projected manpower levels which were submitted in the GE Annual Work Program. It was only an interim Headquarters/Center arrangement until the KSC tasks could be structured to comply with General Phillips' directive to have the major emphasis placed on mission orientated tasks in all possible areas. The Reliability Office was the focal point for pulling together the R&QA requirements.

Attachment A to Appendix 2 provided for the coordination and clarification of the overall KSC reliability analysis program. Attachment (B) was an effort to provide several organizations with general guidance regarding the future use of GE/ASD under NASw-410 in the Apollo Program.

Some level-of-effort tasks could be arranged such as the arrangement with GE for Reliability Engineers to assist KSC Directorates in overall Apollo Reliability Profiles for launch critical systems. Profile reports included failure mode and effect analyses for each Saturn-V launch critical system. Profiles were formally provided at design reviews, etc., as shown on the following APOLLO RELIABILITY PROGRAM chart:

M


APOLLO PDP
APOLLO R&QA PROGRAM PLAN
• REQUIREMENTS
• RESPONSIBILITIES
• RELATIONSHIPS
• CONTROLS
• POLICY
• ASSESSMENT
• MISSION SUCCESS & SAFETY GOALS
APOLLO PROGRAM STANDARDS
• NPC-200-1, 200-2, 200-3
• NPC-250-1
• STANDARDS
• TRAINING
• PROCEDURES
PROGRAM IMPLEMENTATION DIRECTIVES
MSF CEN
• PROGRA
PLAN
• R&QA PR
PLAN
• CONTRA
REL. RE
CONTRA
ACTI
MAO, MAT, MAS, MAP
PROGRAM CRITICALITY ANALYSIS
• MISSION RELIABILITY
• CREW SAFETY REL.
• RESOURCE ALLOCATION
• SCHEDULE IMPACT
• ADEQUACY OF PLANS
• AVAILABILITY (LAUNCH)
MANAGEMENT EVALUATION & DIRECTION
RELIABILITY PROGRAM CRITICALITY SUMMARY & RECOMMENDATIONS
MLL STATUS vs GOALS
OTHER SELECTED MISSIONS STATUS vs GOALS
FEEDBACK
FEEDBACK

The Chief of KSC's Reliability Office also functioned as a Staff Office to the Center Director, and later to the Director of Plans & Programs Resources to develop and establish reliability policy.

NASA Headquarters issued the NASA Handbook, NHB 5300.IA in July, I966, which required each Center to have internal R&QA Plans and Procedures which Headquarters would audit annually. This action precipitated establishment of Quality Offices in each Directorate at the Center. Plans were developed and presented to the KSC Director of Quality Assurance for approval as the Apollo Program progressed. The Reliability Office, headed by Robert Body, became the Apollo R&QA Office, reporting to the Director, Plans, Programs and Resources.

The Director, Quality Assurance instituted the required internal audit program in 1967 which proved effective in more adequate R&QA programs being developed and implemented at Directorate levels. Mr. Richard Teti was remembered as the first R&QA Auditor at KSC. His job was an up-hill struggle for many months because of reports from System Engineers that he was interrupting operations. Teti's acceptance was slow in coming, to say the least.

Also, in that year, NASA Headquarters began the annual audit and survey program of Center R&QA activities. An additional audit function was established in April 1968 for the purpose of assuring implementation and use of approved work procedures. The implementing document for this function initially was KN 5310.1, "Random Audits of Approved Work Procedures." It was replaced in July 1970 by KMI 8610.8/QA, "Random Audit of Work Procedures." Initially the new program was resisted by Center elements because of concern for interference with important work progress and launch vehicle testing in process. In spite of resistance to such a surveillance program, it progressed without interruption of important tests and became an important tool to management for assuring that approved procedures were on hand and in use throughout the Center testing and launching activities.

Mr. Guy Cohen was remembered as the leading Quality Audit representative from NASA Headquarters. His title was Director, Skylab Reliability, Quality & Safety. The first NASA Headquarters audit was performed at KSC in August, 1967 with Random Audits beginning in February,1968. Mr. Cohen attended all or most of them, and his letters of appreciation were well received. His letters of audit findings against KSC were not so well received, but were helpful in finding areas of concern which needed corrective action. One hundred percent corrective action was required in a timely manner back to the NASA R&QA Director in Washington before the defective items were closed out. Such a tight audit program was followed throughout the Apollo, Skylab and Apollo-Soyuz Programs, and the early Space Shuttle Program.

As would be expected in such a vast activity area as launch vehicle preparations and testing, some quality assurance problems and human error incidents were bound to happen. A program which began with ninety-five per cent of the problems requiring extensive recurrence action ended with only three per cent requiring any kind of corrective action. Enabling R&QA documents such as NHB 5300.4(1B), NHB 5300.4(1C), NHB 5300. 4(1A), NHB 5300. 4(2B) proved to be most helpful in providing and assuring reliable launch support equipment for the manned programs at the Center.

CHAPTER 3

EVOLUTION AND IMPLEMENTATION OF R&QA MANAGEMENT AND DOCUMENTATION

On July 16, 1958, the U.S. Congress passed the National Aeronautics and Space Act , creating the National Aeronautics And Space Administration (NASA). The Marshall Space Flight Center (MSFC) in Huntsville, Alabama was made a part of the initial NASA team, who on July 1, 1962, created the Launch Operations Center (LOC) here in Florida. On November 29, 1963, five days after the death of President John F. Kennedy, the Center was named the John F. Kennedy Space Center in his honor.

On November 5, 1958, the Space Task Group (STG) was formed to lead the satellite program planning, execution of design, and development and testing of a manned satellite for America. The STG expanded as the task became more expansive and complex to include more people working in design, procurement and testing areas. This also included necessary people experienced in aircraft quality assurance.

Dr. Wernher von Braun's LOC team was transferred to NASA in December, 1959. This action set the stage for the experience of that team to join with the experience of the Space Task Group to use the Redstone vehicle and the experienced missile launch team at Huntsville and at Cape Canaveral to launch the first Americans into space in 1961. Before, and during these actions, the Mercury Atlas was being tested to allow man to enter into earth orbit after the initial tests with the modified Redstone vehicle were completed. Effective January 1, 1965, the STG contingent under Mr. G. Merritt Preston, was transferred to the Launch Operations Center (LOC) at KSC, headed by Dr. Kurt Debus.

At this point in the history of space flight, a need arose to consolidate NASA reliability and quality assurance management and requirement documentation. NASA R&QA documents from both agencies were adopted, revised, and improved for the LOC procurement program. In 1961, Quality Engineering Bulletins QEB-1, -2, and -3 (Quality Provisions for Government Agencies, Prime Contractors and Suppliers) were used. Then in 1962, NPC 200-1A - Quality Assurance Provisions For Government Agencies, NPC 200-1, Quality Provisions For Space System Contractors, NPC 200-3

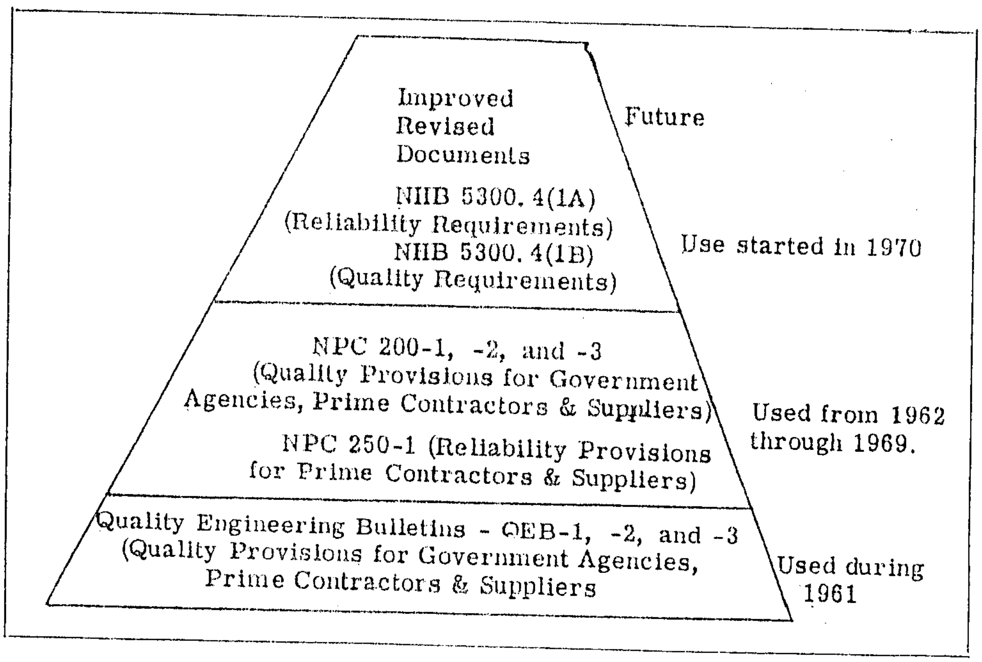
<u>Inspection System Provisions For Suppliers of Space Materials, Parts, Components, and Services</u>, NPC 200-4 - <u>NASA Soldering Specifications</u>, NPC 250-1, <u>Reliability Provisions for Space System Contractors</u>, and others were issued.

These were utilized until 1969, when the following documents were issued as follows:

NHB 5300.4(1B) was issued in 1969 to replace NPC 200-2.
NHB 5300.4 (2B) was issued in 1971, to replace NPC 200-1A.
NHB 5300.4(1A) was issued in 1970, to replace NPC 250-1.
NHB 5300.4(1C) was issued in 1971 to replace NPC 200-3.

Mr. Deter Grau (MSFC), in "Quality Progress, "February 1972, presented the following chart and made this statement:

> "Users of these documents are aware that what is in them existed before 1961 and could have been found by conscientious and knowledgeable interpretation of previously existing documents. What is new is the simple language of the main features and emphasis placed on attention to detail in hardware. We emphasized the necessity of combining theoretical and paper effort and the hardware effort into an integrated program. We have been going this way since the early '60s and the concept has been accepted everywhere much faster and better than we had ever hoped, even if some mumblings were heard and a few stumbling blocks removed."



Mr. Grau continued his statement:

> "When we laid out the pattern for the quality assurance area, we realized that the next step would be to set the frame for a reliability effort based on the same fundamental principle: marriage of the theoretical and hardware efforts. NASA Document NPC 250-1 spells this out. This step was not easy since the theoretical approach prevailing at that time emphasized apportionment and prediction of numerical probability of success. Placing this approach in proper perspective provides a tool that enables us to zero in on problem areas requiring many different engineering disciplines for their resolution. Applying these documents mainly to the Saturn-Apollo project and working with all contractors involved, we found areas requiring clarification and improvement. The combined efforts of NASA Centers, together with input from industry, resulted in revised versions (NHB 5300. 4(1B) and NHB 5300. 4(1A) which became available in 1969." (5)

In the latter half of 1959, as the Space Task Group's quality monitoring effort gathered momentum with various manufacturers, the urgent search for ways to reduce the ultimate risk of sending a man for a ride in an artificial moon lifted by a missile, gradually became more systematic and better organized. It then became clear to all involved that reliability had to be built into the equipment in order to advance the symbiosis of man and missile, of astronaut and capsule.

What about that word, RELIABILITY? Mr. Grau of ABMA Quality Assurance mentioned early in his above statement that the next step would be to set the frame for a reliability effort based on the same fundamental principle: "marriage of the theoretical and hardware efforts."

The quote from THIS NEW OCEAN, NASA SP-4201, 1966 page 178, shows this step being undertaken at the Saturn-Apollo level:

> "Reliability was a slippery word, connoting more than it denoted. Yet, as an engineering concept, it had basic utility and a recognized place in both aviation and missile technology. The quest for some means of predicting failures and thereby raising the odds toward success began modestly as a conscious effort among STG and McDonnell engineers only in mid-1959, after design and development work on major systems was well under way. Other engineering groups working in support of Project Mercury also began rather late to take special care to stimulate quality control and formal reliability programs for booster and spacecraft systems. Mercury would never have been undertaken in the first place if the general state-of-the-art had not been considered ready, but

mathematical analyses of the word "reliability" both clarified its operational meaning and stirred resistance to the statistical approach to quality control.

The fifties had witnessed a remarkable growth in the application of statistical quality control to ensure the reliability of weapon systems and automatic machinery, The science of operations analysis and the art of quality management had emerged by the end of the decade as special vocations. " (6)

The next logical step in the evolution of mission reliability was to Man-Rate the Machines. This quote on man-rating the overall Mercury space program was taken from THIS NEW OCEAN, A History of Project Mercury, NASA SP-4201, beginning on page 179. The following quotes do form a good history of the struggle made in establishing a closer quality and reliability program for the United States' manned launches:

"In view of the fact that estimates showed over 40,000 critical parts in the Atlas and 40,000 more in the capsule, the awesome scale and scope of a reliability program for Mercury; made it difficult to decide where to begin. To organize engineering design information and data on component performance, someone had first to classify, name, or define the "critical parts." To create inter-related systems and to analyze them as separate entities at the same time was difficult. The Space Task Group and McDonnell worked on creation at the expense of analysis through 1959. Gradually NASA Headquarters and Air Force systems engineers steered attention to certain "semantic" problems in the primitive concepts being used for reliability analyses. For instance, what would constitute a system? How should one define failure? What indices or coefficients best 'measure' overall system performance from subsystem data?

These and other features of reliability prediction were so distasteful to creative engineers that many seriously questioned the validity and even the reliability of reliability predictions. Reliability Engineering, admitted one apologist in this field, may seem to be more mysticism and black art than it is down-to-earth engineering. In particular, many engineers look on reliability prediction as a kind of space-age astrology in which failure rate tables have been substituted for the zodiac. Around STG this skeptical attitude was fairly representative. But at NASA Head-quarters, Richard E. Horner, newly arrived in June 1959 as Associate Administrator and third man in command, had brought in a small staff of mathematicians and statisticians. It was led by Nicholas E. Golovin, who transferred from the Air Force to NASA some of the mathematical techniques lending quantitative support to demands for qualitative assurance. Theory-in-Washington Versus practiced-at-Langley were in conflict for a year until the nature of "reliability" for pilot safety on the one hand and for mission success on the other became more clearly understood by both parties. The pressure exerted by Golovin and NASA Headquarters to get the Task Group and McDonnell to change its approach to raising reliability levels became a significant feature in redesign and reliability testing during 1960.

Scientists, statisticians, and actuaries, working with large populations of entities or events, had long been able to achieve excellent predictions by defining reliability as a probability, but in so doing they sacrificed any claim to know what would happen in a unique instance. Engineers and managers responsible for a specific mission or project entities or events, had long been able to achieve excellent predictions by defining reliability as a probability, but in so doing they sacrificed any claim to know that would happen in a unique instance. Engineers and managers responsible for a specific mission, or project tended to ridicule probability theory and to call it invidiously "the numbers game." Being limited to a small set of events and it invidiously forced by time to overlap design, development, test, and operations phases, they could not accept the statistical viewpoint. They demanded that reliability be redefined as an ability. The senior statistician at Space Technology Laboratories for the Atlas weapon system, Harry Powell, recognized and elaborated on this distinction while his colleagues became involved with man-rating the Atlas. His remarks indicated that Space Technology Labs (STL) and Convair/Astronautics faced the same divergence of opinion that NASA Headquarters and STG confronted.

If reliability is to be truly understood and controlled, then it must be thought of as a device, a physical property which behaves in accordance with certain physical laws. In order to insure that a device will have these physical properties it is necessary to consider it first as a design parameter. In other words, reliability is a property of the equipment which must be designed into the equipment by the engineers. "*Reliability cannot be tested into a device and it cannot be inspected into a device; it can only be achieved if it is first designed into a device.* " Most design engineers are acutely aware that they are under several obligations; to meet schedules, to design their equipment with certain space and weight limitations, and to create a black box (a subsystem) which are fed into it. It is imperative that they also be aware of of their obligation to design a device which will in fact perform its required function under operation conditions whenever it is called upon to do so.

There is a rule in Probability theory that the reliability of a system is exactly equal to the product of the reliability of each of its subsystems in series. The obvious way to obviate untrustworthy boxes in parallel to perform the same function was the technique most often used to ensure reliability.

After the cancellation of Mercury-Jupiter, Kuettner and others at ABMA set about a serious effort to develop a parachute system to recover the Redstone They also began to concentrate on the simplification necessary for the sake of reliability to custom-build a man-rated Redstone. Starting with the advanced, elongated version of the rocket, which had been renamed the "Jupiter-C" in 1956 for the Army's ablation research on reentry test vehicles, Kuettner called upon the expertise of all who could spare time from the Saturn program to help decide how to man-rate their stock. The fundamental change made to the Jupiter-C airframe was the elimination of its staging capability. Other modifications stripped it of its more sophisticated components while permitting it to retain greater Performance characteristics than the original single-stage Redstone.

On July 22, 1959, STG engineers received a group of reliability experts

> from von Braun's Development Operations Division at Huntsville. Three decades of rocket experience had ingrained strongly held views among the 100 or so of rocket leaders of this organization about how to ensure successful missions. The ABMA representatives told STG that they did not play the "numbers game" but attacked reliability from an exhaustive engineering test viewpoint. Their experience had adequacy of their own reliability program, carried out by a separate working group on a level with other engineering groups and staffed by persons from all departments in the Development Operations Divisions of ABMA. In conference with design engineers, ABMA reliability experts normally set up test specifications and environmental requirements for proving equipment compliance. STG felt sympathetic to this approach to reliability, but systems analysts at NASA Headquarters did not.
>
> As for the prime contractor's reliability program, in the first major textbook studied by the astronauts, McDonnell's "Project Mercury Indoctrination" manual, distributed in May 1959, the pilots read these reassuring words: "*The problem of attaining a high degree of reliability for Project Mercury has received more attention than any other previous missile or aircraft system. Reliability has been a primary design parameter since the inception of the project.*" (7)

As the space program advanced into the Mercury-Atlas phase, more faith was placed in quality assurance procedures and in redundant system development, than in mathematical models or reliability prediction during design. This concept prevailed throughout the manned space flight program, in spite of counter recommendations by the General Electric Apollo Support Department (ASD), working under NASA contract, NASw-410.

The Launch Operations Center (LOC) {which later became Kennedy Space Center (KSC)}, reliability personnel placed emphasis on analysis and non-quantatative techniques for identifying critical parts and systems in lieu of mathematical models and prediction. The heart of the reliability analyses became the failure mode and effect analyses, and rigorous evaluation of actual failures, and assisting design engineers in establishing redundant and back-up systems and components.

Much good was accomplished by GE-ASD, but not in the area of math modeling and recommended prediction programs. R&QA Surveyors' Training Course, designed and conducted by GE A. S. D., was well received by NASA personnel needing such training. The course was tailored toward people who visited hardware contractor facilities for audit and survey purposes. The course was designed around the NPC series of R&QA documents, and GE-ASD contributed substantially to NASA/Industry's understanding of the documents.

Reflecting back to the importance of Reliability & Quality Assurance surveillance of the contractors providing support to the space program, one may wonder how this was accomplished in the real world of government contracting.

The U.S. Government MEMORANDUM, dated May 16, 1968, found in Appendix 3, shows how this was accomplished. It was accomplished through appointment of a Contract Technical Manager and a Reliability and Quality Surveillance Alternate Technical Representative for each Center contract which required such formal monitoring and evaluation of contractor performance. A typical Acceptance letter is shown on page 5 of the Memorandum.

The Position Record, dated October 19, 1966, found in Appendix 4, shows how the Quality Surveillance Representative was tasked in writing to implement the numerous detailed responsibilities at the Center Directorate level.

The Memorandum, dated March 17, 1965, Subject: Reliability Program Requirements for Hydrogen Fire Detection System, found in Appendix 5, shows correspondence between the Reliability Engineer and the Design Engineer which ultimately went into the contract for a Hydrogen Fire Detection System. Even though the system was made up of off-the-shelf sub-systems, the overall detection system was "launch essential," which then demanded reliability elements (a) through (m) be invoked in the contract. The second paragraph on page 3 shows that the KSC Quality Assurance Office would provide the appropriate quality assurance requirements for the contract; paragraphs (b), (d), (f), (g), and (h).

This division of responsibility for reliability and quality assurance was followed throughout the buildup of the Saturn and Apollo support systems at KSC. Reliability Engineers were tasked to cover reliability requirements and contractor surveillance in their respective Directorates, while Quality Engineers were tasked to provide quality assurance requirements and surveillance of contractor work across the Center, after the Army Corps of Engineers completed their work at KSC.

Both Reliability and Quality Engineers followed KSC's Kennedy Management Issuance (KMI 1710.1) in day-to-day responsibilities. Quoting from that document:

> ...."that it is KSC policy to incorporate appropriate reliability and quality assurance requirements in procurements. It further states that requirements will be tailored to the criticality, complexity, state-of-the-art, cost, schedules, and the amount of research and development required by the contractor." (8)

The assigned KSC Reliability Engineer, working with Design and Procurement, reviewed each contract for launch critical systems, and recommended the following reliability elements to be invoked in accordance with the above policy:

RELIABILITY REQUIREMENTS

Off-the-shelf boilerplate requirement
Contractor reliability statement
Design Specification
Reliability Prediction/Estimation
Failure Mode & Effect Analysis
Maintainability
Design Review
Failure Reporting & Correction
Parts and Materials Program
Parts Selection
Equipment Logs
Reliability Testing
Reliability Assessment
Reliability Progress Report
Reliability Program Report

This reliability requirement matrix of the above NASA Apollo ground support equipment, shows what detailed planning and follow-up with hardware contractors was required by KSC Reliability officials. The assigned Reliability Engineer followed up procurements and visited most of the manufacturers for survey and coordination purposes. Contract sign-off was also required by the R&QA representatives. (See Appendix 8)

The KSC Quality Assurance Office provided and coordinated all quality requirements directly with the Technical Directorates and invoked quality assurance requirements in appropriate contracts in their areas of responsibilities. They followed up procurements with either visits to the manufacturer's plant or coordinated with Government Agencies on site for their assistance in monitoring a KSC contract.

The following NASA documents were followed in performing this very important government function as launch-critical systems/equipment were purchased and subsequently survailed by KSC engineers:

KMI 5310.12A/QA: Incorporation of Reliability and Quality Assurance Requirements in KSC Procurements
NHB 5300.4(ED): NASA Procurement Regulations

Appendix 6, "A Technical Paper, Incorporation of Reliability Requirements into KSC Procurements," provides detailed implementation instructions for each important reliability requirement paragraph used in KSC contracts. This Technical Paper was written in 1975 as an aid to Reliability Engineers working with procurement personnel at KSC.

Quality Inspection Is a key implementing activity for making sure that engineers and technicians are doing their jobs responsibly. Early in the Saturn-V program many qualified technicians were transferred to quality assurance offices. They were given the required training to do their job of quality inspection. Structured training in all aspects of R&QA were required for each newly assigned quality analyst/ inspector. Quality Assurance Status Stamps shown below were issued and controlled by each KSC R&QA Office's Stamp Custodian. Notice that each analyst/inspector was assigned a number for identification back to the official quality action taken by the individual:

Conformance Stamp - Triangle stamp (

) used to indicate that articles and/or accompanying documents satisfy NASA requirements and conform to prescribed criteria.

Nonconformance Stamp - Hexagon stamp (

) used to indicate that articles and/or documents have been inspected and/or tested, but do not conform to requirements. Such articles and documents are subject to further corrective action, inspections, tests, investigations, processing, or contractor actions.

Void Stamp - D-shaped stamp (

) used to indicate that previous Government inspections, tests, and accompanying documents are void.

Surveillance Inspection Point (SIP) Stamp - A square stamp (

) used real time to identify certain tasks, operations, or processes on future work steps that NASA Quality must verify.

NASA Quality Inspection Stamps

The assigned Stamp Custodian maintains a secure listing of all persons who have custody of a set of quality assurance status stamps and lead-wire pliers. He or she investigates all loss of stamps and pliers, and records the re-issuance of new ones. All lost stamps or pliers are thoroughly documented and records kept in case they are found. The issuance of these important tools-of-trade for quality inspectors sealed forever their importance and status in assuring a disciplined quality assurance program at KSC.

A most important Apollo and Shuttle R&QA function Is the audit and survey of R&QA activities within both NASA and in the contractor day-to-day work. The audit and survey organizational evolution is documented in the Quality Assurance Office Chief, Mr. R.A. McDaris' memorandum of October 3, 1980, shown in <u>Appendix 7</u>. The following data taken from that document shows major audit and survey activity for McDaris' staff:

a. Conducts formal configuration management, safety, reliability, and quality assurance program surveys of KSC organizations, on-site government agencies, and on-site contractors.

b. Documents and reports the status and results of the formal surveys to KSC management. Presents deficiencies at closeout sessions with government/ contractor personnel, recommends corrective action, and performs follow-up audits as required.

c. Conducts special investigations of safety and reliability and quality assurance requirements and program problems.

d. Performs random audits of work procedures throughout the KSC work areas and reports result to KSC government/contractor management levels as determined necessary.

e. Participates in surveys of other NASA centers upon request of NASA Headquarters.

f. Participates in, or assists NASA Headquarters in surveys of KSC.

g. Develops the KSC master survey schedule. distributes quarterly to the appropriate organizations a planned six-month survey schedule of on-site and Procurement Office off-site surveys.

h. Assists in the preparation and maintenance of the necessary plans, procedures, and controls for implementing an effective safety, reliability, quality assurance and configuration management survey and audit program.

i. Assists in the review of government/contractor configuration management, safety, and R&QA Management instructions and procedures. (9)

This KSC audit and survey program during Apollo launches was carried over into the preparation of handling and launch support facilities, and ground support equipment for the first Shuttle launch planned for the early 1980's.

The handling, storage, and preservation of materials, from the early missile launches at Cape Canaveral until today, has been a very important element of launch operations. Early Redstone and Jupiter launches by the Missile Firing Laboratory from Redstone Arsenal, recognized the importance of assuring the integrity of spare parts and materials for the preservation and integrity of all flight spare parts, and Line Replaceable Units (LRU's). Mr. Robert Green was assigned as the first person to lead the way. A special building was erected in the Hangar"D"/Hangar"R" compound at the Cape just for assuring proper handling, storage, tracking and preservation of important spare missile parts and materials. The effort became more important as the space program opened up to manned ventures into space. Many improvements were made as the activity called, "Logistics," was given more attention and more efficient and secure systems were instituted at KSC.

Issues of the KSC SPACEPORT NEWS have shown a trail of quality improvement actions which are important in the history of KSC's R&QA program over the years of operation at Cape Canaveral and at Kennedy Space Center. The first remembered action took place when in 1983-84, KSC adopted the program for Productivity Improvement and Quality Enhancement (PIQE). Copying from the February 17, 1984 issue of SPACEPORT NEWS:

> "There's a new acronym making the rounds of KSC -- PIQE, short for Productivity Improvement and Quality Enhancement.
>
> Destined to become familiar to all employees, it is NASA's response to President Regan's call for all federal agencies to improve America's competitive ability in the world marketplace through increased productivity and quality of work.
>
> PIQE's objective is simple: to stimulate and increase employee motivation, commitment and capability towards getting the job done better, faster and more economically.
>
> KSC, as the nation's major launch facility for space flight, has the opportunity to become a pacesetter for PIQE, because of its varied functions and its interrelated work force that combines the best of government, industry and the educational community.
>
> PIQE is guided at KSC by the center's Productivity Council, which serves as a catalyst for productivity improvements. It consists of representatives from the line directorates and the American Federation of Government Employees (AFGE), plus ex-officio members from Executive Management, Legal, Personnel, Public Affairs and Safety staff offices.
>
> Current council members are Dallas Gillespie, AC; Steve Harris,DD-MED; Jim Summa, SI-PRO-4; Bill Huseonica, SM-ANA; Tom Martin, CM; Saul Barton, PM; Dick Mundy, CC; Bill Schick, SF; Ray Corey, PA EAB; Warren Camp, EX-MPR; and Gatha Cottee, PA-PIB, representing AFGE.
>
> In addition to implementing and monitoring the PIQE program at KSC, the council is responsible for keeping the KSC Senior Staff informed of its activities and plans. Gillespie, who serves as chairmen, interfaces with David Braunstein of NASA Headquarters, named Executive Director of Special Projects by Administrator, James Beggs. Beggs chairs NASA's steering Committee for PIQE, a group including all center administrators and assistant administrators.

Some of PIQE's major objectives at KSC are:

1. Increasing Civil Service productivity motivation through seminars, lectures and workshops, and wider training.
2. Revitalizing employee suggestion and award systems.
3. Encouraging and supporting NASA Employee Teams (NETS) and Quality Circles.
4. Holding contractor workshops to deal with impediment issues and to discuss productivity programs.
5. Initiating concentrate efforts to make use of automation.
6. Recognizing employees for their productivity accomplishments.

KSC employees are being encouraged to participate in a significant way in productivity and quality improvement. Gillespie emphasized, "It is a real opportunity to utilize the innovative ideas of our work force as a means to upgrade and extend our capabilities.

In future issues, Spaceport News will explore in detail the six focus items of KSC's PIQE program, and report on their progress." (10)

A new concept first promoted by Dr. Edwards Deming, an American leader in Total Quality Management (TQM), was first reported in the November 2, 1990 issue of SPACEPORT NEWS, pages 1 and 4. (Dr. Deming visited KSC when the push was on to develop a cadre of R&QA engineers to organize and lead an effective R&QA program for the Apollo Program. Dr. Deming helped the Japanese automobile industry and electronics industry to set new standards for quality and production after World War II):

"Our task, together, is to turn our vision of the future into reality...to carry out our missions with the utmost attention to total quality and productivity...(and) to apply unwavering standards of excellence: Admiral Richard H. Truly, NASA Administrator, told approximately 700 agency and company representatives at the Seventh Annual NASA/Contractors Conference last week.

The conference, with a theme of Total Quality Leadership, was held Oct. 24-25 at the Grenelefe Resort and Conference Center, 30 miles west of Orlando. The annual meeting provides a forum for NASA and contractors to exchange strategies for quality and productivity improvement.

Truly told the participants that the space program today stands at a crossroad. He said, "We are entering a new age of space exploration where we will find countless doors of opportunity...to learn more about this precious planet we live on, about our neighboring planets, and about what lies beyond our solar system. We have the opportunity to establish a permanent presence in space, colonize the moon and explore the planet Mars."

Whether or not America actually chooses to pursue this effort will depend on the people in this room," he cautioned the Conference participants. "If we are to place humans on the planet Mars by 2019, then each of us must be committed to total quality leadership in everything we do.....leadership and quality and excellence will be the key to this new age."

Citing George Low as the example for conference attendees to follow, Truly said that the former acting NASA Administrator's personal commitment to quality and excellence was the driving force behind the historic first landing of men on the moon during the Apollo program.

"George Low represented quality and excellence like few others," Truly emphasized. "He practiced TQM long before it became the management word. Our charge at this conference is to discuss ways to build on the legacy that George Low left us."

To reaffirm NASA's commitment to Low's philosophy, Truly said that he had changed the name of the agency's annual Excellence Award, presented each year to NASA contractors during the conference, to the, "George M. Low Trophy." The 1990 recipients of this award are Rockwell International Space Systems Division and Marotta Scientific Controls, Inc.

"Since 1958, contractors have been an integral part of NASA and our stunning successes," Truly pointed out.

However, the NASA Administrator also stressed that along with the pride in past accomplishments there must be a commitment to continued excellence in the great challenges that lie ahead.

"If we all take part and share with each other our best ideas, we will remain the world's leaders in space," Truly emphasized. "If we mutually commit to continued total quality excellence, as a management philosophy and as a way of doing our daily business, there will be no limit to our achievements." (11).

This was a large goal that Administrator Truly laid out for NASA employees in this study in Total Quality Management. In the same issue of the SPACEPORT NEWS, page's 1 and 7, we found evidence of how KSC viewed Truly's challenge as he talked about how KSC would attempt to challenge and prepare KSC employees to embrace TQM:

"The quality of the work force, and the work performed by the Kennedy Space Center team has always ranked with the best in the world, Center Director Forrest McCartney told a gathering of NASA and contractor managers recently. "However, maintaining that excellence and improving on it is a never-ending process and Total Quality Management (TQM) will help us achieve that goal."

McCartney has appointed Deputy Director Gene Thomas to oversee all of the TQM efforts at KSC and serve as chairman of the TQM Committee. "TQM is a work philosophy which has led to dramatic quality and productivity improvements at NASA, other governmental agencies and big business. It has been so successful that President Bush has advised all government agencies to adopt it," Thomas reports. "In response, NASA Administrator Richard Truly has issued instructions for all NASA centers to establish TQM plans."

The TQM Steering Committee at KSC, chaired by Thomas and consisting of eight other senior NASA/KSC managers, is tasked with the overall leadership and development of TQM policies and direction.

McCartney appointed Warren Camp as chief of the TQM and University Liaison Office within Bill Rock's Advanced Projects and Technology Office. Dr. Albert Koller, from that office is chairing the TQM Action Committee that is charged with implementing the steering committee policies.

A third committee, the TQM Integrated Working Group, is comprised of steering committee members and representatives from nine major KSC contractor companies. This group held its kickoff meeting Oct.1, and will work to integrate the KSC TQM plan throughout the center.

TQM is the outgrowth of the work which W. Edwards Deming did in helping the Japanese industry emerge from almost total devastation during World war II to setting new standards of quality in automobiles and electronic products," Thomas points out. "It focuses on the customer, both internal and external, and a process of continual improvement. It stresses training of every employee, empowerment of employees to effect change, a team approach, measurable performance and a philosophy of doing the right thing the first time.

We're now in an early phase of implementing TQM," Thomas stated. "A Kennedy Management Instruction is presently being completed that defines the TQM responsibilities of everyone at the center. Also, we have begun educating top management in the TQM philosophy."

"TQM will fail without the total commitment of management at all levels, and especially at the top," he emphasized.

Dr. Koller attributes the success of TQM to its ability "to significantly increase the individual's influence on the product or service." With TQM, Koller says, "employees can see that they do make a difference and have the means to do so.

Moving from the present to a TQM culture is an evolutionary process that will take several years, Koller believes. The KSC goal is to provide TQM training to every employee.

"TQM has already garnered the largest body of industry supporters of any management approach I have ever known," Koller says. "Its popular because it combines all of the sound management theories into one vehicle."

Camp points out that several major aerospace corporations have initiated successful TQM efforts to improve efficiency and reduce costs. Other large companies such as IBM, Westinghouse, Xerox and Hewlett-Packard have also embraced this concept to successfully reverse their downward business trends. Still other companies can credit their survival to the adoption of TQM principles.

"Although KSC management can learn much from the successful way others have implemented TQM, the center cannot adopt their plans," Camp emphasizes. Instead, he says, the KSC plan must be tailored to specific KSC needs.

KSC management does not see TQM as a totally new concept, Camp says, It is viewed as building on the work of the past and a natural evolution of the quality process that has always existed at the center.

"TQM also fits in here because it is strongly team oriented, " Camp says. "Teams are a way of life here at KSC. The difference is that the TQM process is an opportunity to create teams not just for problems solving but for continuous improvement as well."

"TQM is also oriented toward the individual," Camp says. "For each individual to make the process work best for them, employees should think about what they can do to provide a better product or service to a customer. In TQM, everyone is a customer, from a co-worker who asks for information, to a company that needs to know how to become a KSC contractor," he explains.

"TQM is a better way to generate new ideas and interest about quality and the saving of limited resources. In these times, everyone at KSC needs to be working toward these goals," Camp concludes." (12)

This November 1, 1990, issue of SPACEPORT NEWS here at KSC has been helpful to historians in faithfully providing the detailed information of the beginning, and of the need to embrace TQM as a management philosophy. The "small-team-work-ethic of the original launch teams at the Cape was embracing TQM before we heard of Dr. Deming, but in large organizations like KSC and most of industry who are trying TQM, the philosophy should work much better in establishing a quality-conscious work force.

In Chapter 3, we have tried to document the evolution of R&QA at KSC. The proceeding quotes from KSC'S newsletter, SPACEPORT NEWS, has been most helpful in that evolution.

The PIQE program that was established early in the Shuttle Program is still going forward at KSC. The February 10,1995 issue of Spaceport News gives an account of the President's Quality Improvement Prototype Award to KSC:

"Kennedy Space Center employees welcomed last week's announcement made by the Federal Quality Institute to Center Director Jay Honeycutt that KSC has been selected as a winner of the President's Quality Improvement Prototype Award.

In announcing the award to KSC employees, Honeycutt praised the thousands of KSC workers who have been involved in improving processes and safety, and reducing the cost of the program to the American taxpayer. "It is an effort we are committed to continuing," he said.

Gene Thomas, deputy center director, said upon hearing the news, "This is significant recognition of our focus on quality, adding value for our customers and making our center's civil service and contractor work force the best in the world.

"Last year, KSC was a finalist for the quality prototype award. After continuing to make significant improvements, KSC has now been recognized as a winner," Thomas said.

James I. Jennings, director of Human Resources, also recognized KSC employees and added that JoAnn Morgan, director of Safety, Reliability and Quality Assurance, and Mike Winchell, chief counsel, played a key role in leading the center's efforts in getting ready for and hosting the on-site visit by the examiners of the Federal Quality Institute.

The president's Quality Improvement Prototype Award recognizes federal organizations that are leading the way in implementing quality management and achieving high standards of customer satisfaction. In receiving this award, Kennedy Space Center joins a select list of top federal agencies that have demonstrated outstanding achievement and quality management.

Dick O'Brien of the Federal Quality Institute said that KSC was one of five of the 32 applicants for the President's Quality Award to receive an award. It's highly competitive and a big distinction for an organization to be recognized," he said.

While only one organization was nominated for the Presidents Award, and that nomination is subject to President Clinton's approval. "KSC is a 'high-performance organization' to receive the Quality Improvement Prototype honor," he said. The Award will be presented to Honeycutt by Vice President Al Gore at the Eighth Annual Conference on Federal Quality in Washington, D.C. in July. (13)

One can see great continuity in the President's Quality Award program as we look at the KSC SPACEPORT NEWS of October 24, 1997:

> "Nine NASA and contractor employees of Kennedy Space Center were honored this year with the Quality Assurance Special Achievement (QASAR) award for exemplary performance in contributing quality products and/or services to the space program." Richard Carlson of Rocketdyne, Clark Creery, of Boeing, Patrice Henson of USA, James Keller, I-NET, James Davis of NASA, David Law of USA, Timothy Wright of USA, J. Mica Parenti of NASA, and Gary Hendrickson of Boeing received the award." (14)

The evolution of R&QA continues today under Continual Improvement (CI). This whole process of harnessing management and space employees into a close launch team, is called, "Continual Improvement." It has the same goals as the Productivity Improvement and Quality Enhancement program (PIQE), established in 1984, Total Quality Management (TQM), established in 1990, and the Structured Survaillance Program, established in 1993. The following brief history of Quality Management was provided by the Continual Improvement Representative:

KENNEDY SPACE CENTER History of Quality Management

Quality management has evolved as an integral part of operations since the Center was established in 1962.

Top KSC executives recognized that we should improve our quality and procedures while emphasizing safety as our number one priority. Improvement activities focused on four areas:

- reduce the number of shuttle and payload activities,
- strengthen partnerships with our customers and suppliers
- expand employee empowerment, and
- use the Total Quality Management/Continual Improvement (TQM/CI) process to accomplish these changes.

1987 The first formal KSC Strategic Plan was developed.

1990 KSC participated in a NASA internal assessment, using the President's Award criteria but elected not to submit an application to the Federal Quality Institute.

1991 KSC Strategic Plan was rewritten with more specific goals and an added emphasis on TQM/CI and Kennedy Management Instruction (KMI) on TQM/CI was implemented.

1991 KSC contracted with the Cumberland Group, a national consulting firm, to provide a basis for TQM implementation. By the end of the year more than 80 percent of our employees had participated in workshops and received TQM training

1992 The KMI was revised.

1993 A NASA-KSC team developed a new mission statement while another team formulated a new Strategic Plan. A third team developed and published the first CI Plan.

1993 The Center Director wanted an external assessment of progress in CI, and KSC applied for the Improvement Prototype Award and was selected as a finalist.

1993 KSC Structured Surveillance Program implemented (discussed in chapter 5).

1995 KSC received the President's Quality Improvement Prototype Award. KSC was also named a finalist for the Florida Governor's Sterling Award.

1996 KSC was named a winner of the Presidential Award for Quality Special Achievement.

As one reads about the NASA effort to improve safety, reliability and quality assurance, it is clear that KSC has continued to make progress in the Continual Improvement management concept in our country's important business of space exploration which deserves the appreciation of all our people.

The latest SR&QA management system is implemented by combining the KSC Business Management System Manual (KDP-KSC-M-1000), and the KSC Safety and Mission Assurance (S&MA) Annual Operating Agreement (AOA) For FY 2002 and Out-Years (KCA-1702, Rev.A). "The Introduction" to the AOA includes these guidelines:

> (1) Plan S&MA functions to meet the institutional, program and project customer requirements; (2) establish a basis for negotiating at the Center and Agency level a resource allocation necessary to meet program requirements; and (3) provide metrics for management of the Center S&MA resources. The AOA process encourages continuous improvement and program and project feedback.(15)

The KSC Business Management System Manual, (Rev. G) beginning on page 15, provides the following major Mission Assurance program elements:

> Control of Customer-supplied Product
>
> It is KSC's policy to control customer-supplied product from receipt until return to the customer or until the incorporation of the product into higher-level assemblies. Identification of product defects upon receipt of hardware is recorded, investigated and reported to the customer upon identification of a problem. Loss or damage to hardware during processing is dealt with in a similar manner. Customer-supplied product problems caused by KSC personnel are recorded in the KSC corrective action system.

Product identification and Traceability

Where contractually specified or in line with KSC policy, identification and traceability subsystems are established to control materials, including their source data. Controls are initiated at the contract award stage and, in many cases, extend through manufacturing and acceptance for incorporation into higher-level assemblies.

Controls are maintained to incorporate engineering changes that alter product configuration. As required, additional documentation is generated reflecting new product identification and corresponding re-identification of the part while maintaining traceability.

Process Control

Procedures and instructions are developed on an ongoing basis by functional managers to ensure assembly, processing, mission and support activities are performed under controlled conditions. Process control procedures include contract management activities and administration of award fees, as well as hands-on processing. Process control requirements are met for each specific area as follows:

- development of procedures to control activities
- use of suitable equipment
- conducive environment for performance of work
- compliance with internal and external documentation
- process monitoring
- approval of new equipment and processes as they are implemented
- workmanship standards

The activities subject to control and management oversight include:

Assembly processing
Award fees
Biomedical operations
Contract management
Customer Opportunity
Equal opportunity
Expendable Launch Vehicles.
Finance
Independent Assessment
Information technology
Installation operations
International Space Station processing
Laboratory practices
Legal

Logistics
Payload carriers
Payload processing
Personnel
Public relations
Safety and quality
Shop operations
Spaceport Services
Space Shuttle processing
Space Station Hardware Integration
Special projects

Special processes are operated both at the Center and at the facilities of our contractors.There are controls to ensure that special processes are performed under suitable environmental conditions by qualified people. Control points are established during the contract award phase, which includes the assessment of the contractors' abilities to meet contractual requirements.

Inspection and Testing

KSC personnel are required by the Federal Acquisition Regulation to perform receiving inspection on procured items prior to use. This regulation does not permit the bypass of material inspection when items are urgently required; therefore, a subsystem for this activity does exist.

Documented procedures for all inspections and tests are established or are developed, as required. Inspections and tests on items produced through experiments and laboratory activity are performed by both KSC and contractor personnel.

KSC's final acceptance of previous inspection and test results is performed in accordance with individual program plans. Authorization by close-out and sign-off of all associated documentation is completed prior to transfer to a contractor of final release of the product.

Individual directorates and prime contractors jointly hold records of inspections and tests. Contractors in various locations retain completed records across the Center. In addition, Certificates of Flight Readiness (COFR) are completed prior to vehicle launch and retained by KSC.

Integrity of Inspection and Testing Equipment and Verification of Test Application Software

The integrity of equipment and software is an extremely important aspect of KSC's activities. Accurate instrumentation and application of verified software are critical to mission success. To this end, calibrations and verifications are performed by onsite laboratories and in contractor laboratories when required. The intervals for hardware calibration have been established. These intervals are monitored and amended on the basis of laboratory results. In some cases, infrequently used items are calibrated on each occasion prior to use. Appropriate operational and storage conditions are maintained to continue accuracy through to the use period of the equipment.

Test Status

Various methods of demonstrating test status of hardware or verification of software are utilized at KSC. Inspection, test, and verification records are a secondary indication of the inspections, tests, and/or verification performed, the test status of the item, and whether the item is acceptable for use.

Nonconforming Product

KSC personnel are involved in the administration and decision-making of disposition of contractors' nonconforming products. In some cases, KSC personnel are solely responsible for the disposition, resolution, and treatment of a defective product. Since KSC is primarily a nonmanufacturing environment, KSC's involvement in product treatment is limited.

The problem reporting systems are managed by the Center, but are primarily used by contractors to communicate the status of nonconforming products. KSC personnel are responsible for monitoring contractor problems and their respective corrective actions, and for reporting adverse trends or conditions to management.

Corrective Action

KSC developed and operates an extensive corrective action subsystem. This covers business management system improvement, control of government contractors' nonconforming products, and general customer complaints. Corrective action is implemented to improve operations and the communication among employees, senior management, and contractors. Problems found during internal audit are documented in the Internal Audit System (IAS) while all other problems, including external customer complaints, are reported in the Customer Forum (Opportunity for Improvement) System.

Preventive Action

All managers are responsible for analyzing available data to assess when action is necessary to prevent a problem. Preventive actions are formally reported and evaluated for Center-wide impact and for further action during management review.

Continual Improvement

Continual improvement is an integral part of the business policy. Civil Service improvement activities at KSC are primarily initiated by either internal audit or Center personnel when opportunities for improvement are reported to management. When required, management creates teams to investigate opportunities for improvement and to develop innovative solutions. Criticality, risk, cost, cost reduction, safety, and feasibility are the criteria used to determine when corrective action will be taken.

Material Handling, Storage and Holding, Protective Packaging, Material Maintenance, and Transportation

Material Handling

Extensive handling operations of component hardware, equipment, chemicals, and living organisms are used at the Center. Protective measures are required when preparing these materials in readiness for movement. Replacement and procurement of handling systems are important elements of these operations.

Storage and holding

Adequate holding facilities for stored materials are established, including secure conditions. Materials are identified and given storage locations for ease of retrieval. Environmentally controlled conditions are maintained where appropriate to preserve those materials subject to deterioration and/or limited life.

Protective packaging

Suitable packaging is either designed or procured by the Center to protect materials. This protection is extended to include storage, holding, movement, and/or transportation to other Center locations, vendor facilities, and space missions. Where required, instructions are issued to handlers to ensure material integrity is maintained. Labeling of material while packaged is an integral aspect of the packaging process.

Material maintenance

In many cases, materials require maintenance before being installed, utilized, or incorporated into higher-level assemblies. Controlled maintenance recall systems are in operation by our contractors to inform custodians when maintenance of materials should be performed.

Transportation

Where the Center is responsible for movement of materials, the nature of the material is assessed to determine the protection required to maintain integrity. Controls extend to vehicle selection and securing and transportation conditions. Transportation instructions are developed to maintain the integrity of materials while in transit.

Record Collection and Retention

Each director has the responsibility to document the KSC Business Record Matrix with required collected data to be retained by their staff. The record matrix includes staff responsibilities, retention periods, storage, and archive locations with the minimum required data with regard to record collection and retention. However, it is an acceptable practice for directorates to add additional information to the matrix.

KSC's record retention arrangements established by KSC's record manager, in accordance with NASA AND NARA Regulations (reference NPG 1441.1), enable effective management review of this system to maintain the confidence of management, customer and internal and external auditors.

Internal Audit

A program of internal audit is established at KSC to evaluate the ongoing implementation, applicability, and value of this business management system. Internal audit schedules are developed through the management review process upon request, by each directorate's/office's management. Nonconformaties are immediately documented in the Internal Audit System (IAS) and, following corrective action, are also subject to management review.

All KSC audits are performed by auditors outside their directorates or program offices.

It is KSC's policy to reserve audit resources for those areas where problems occur or where operations are viewed as critical to mission success. Matrics information is used to assist in determining where audit resources are required.

All KSC internal auditors have undertaken a minimum of 24 hours of formal auditor training.

Training

KSC's policy is to provide training for all NASA personnel at the Center. Training requirements are divided into required and development training elements. Employees are not permitted to perform all aspects of their work until required training needs for each aspect have been satisfied. Required training is documented on the Center-wide Required Training Plan for all employees who require training following assignment to a position. The plan gives the minimum data with regard to required training; however, it is an acceptable practice for directorates to add additional information to the matrix if it proves helpful. In addition, directorates have databases that enable them to monitor developmental training which is not subject to the requirements of ISO 9001-1994.

Personnel training needs have been established for all work activities. Training is performed both on-the-job and through formal instruction, including academic training, in order to further fulfill the needs of the Center for specialized skills and expertise. Training records for on-the-job training are maintained by each directorate for its employees. Records of formal training are maintained in procurement and training records. Employees were previously qualified on past experience; and therefore, training records for required (on-the-job) training performed before April 23, 1998, have been retained.

On an annual basis, the Center Director determines appropriate training to be mandated for the fiscal year. Mandatory training in some cases is necessary to fulfill legislative requirements. This training includes any pertinent training that is required to fulfill the needs of the Center in a given year.

Individual career enhancement training requirements are identified in Annual Training and Development Surveys and Individual Development Plans. Records of completed developmental training are contained in the ASTAR automated training system that is managed by the Workforce and Diversity Management Office.

The procedure for personnel training can be found via electronic media through the Business World web page or the Technical Documentation (Tech Doc) database.

Servicing

The Kennedy Space Center civil service employees do not perform servicing activities on KSC's products.

Performance Indicators

KSC does not use the application of statistical techniques to confirm process capability.

Statistical techniques, however, are deployed in some directorates for the purpose of assessing contractor performance. In this case, the activity is managed through Process Control. (16)

The methods used in all these Mission Assurance functions are found via electronic media through the Business World Web page or the Technical Documentation (Tech Doc) database.

These implementing documents do not require the usual KSC "R&QA Program Plan," as such. Instead the Kennedy Space Center Business Management Manual and the Safety and Mission Assurance (S&MA) Annual Operating Agreement (AOA) For FY 2002 And Out-Years are deemed adequate to implement R&QA programs for the center. Appropriate elements of these manuals are included in KSC support contracts as appropriate.

CHAPTER 4

HISTORY OF R&QA IN THE SATURN-APOLLO PROGRAM

On July 16, 1958, Congress passed the Space Act of 1958, creating the National Aeronautics and Space Administration (NASA).

Space oriented Army facilities and personnel resources were merged with the National Advisory Committee for Aeronautics (NACA) to form the nucleus of NASA. Thus NASA was born - an agency especially formed to establish and pursue a program of peaceful space exploration. At the same time NACA's original aeronautics research program was to be pursued. The amalgamation of these agencies, along with additional personnel from phased-down programs, brought together able scientists and engineers to form the new agency.

The Army Ballistic Missile Agency (ABMA) personnel at Cape Canaveral under Dr. Kurt Debus, were transferred to NASA as part of the Marshall Space Flight Center's Launch Operations Directorate (LOD) in December, 1959. The LOD began to organize itself to support the NASA programs as well as supporting the continuing ABMA launches such as the Redstone, Pershing, and Jupiter missiles, as well as the beginning Mercury-Redstone science and primate launches. On July 1, 1962, the Launch Operations Center (LOC) was formed at Cape Canaveral.

Among the first R&QA efforts within the LOC was establishment of a test instrument calibration and recall system. This was accomplished within the Electronic Engineering, Measuring and Tracking Branch under Mr. Karl Sendler. The author was assigned to help with that effort, and was also responsible for establishing an automated ALERT program. The ALERT system utilized the IBM card system for expediting the response to ALERTS which could affect the Telemetry and Tracking systems in Hangar (D) at the Cape. Each piece of equipment in both of the launch mandatory systems was inventoried for critical components. The identity of each component was fed into the IBM card reader so that ALERTS from Huntsville or other Centers could be found quickly and corrective action taken.

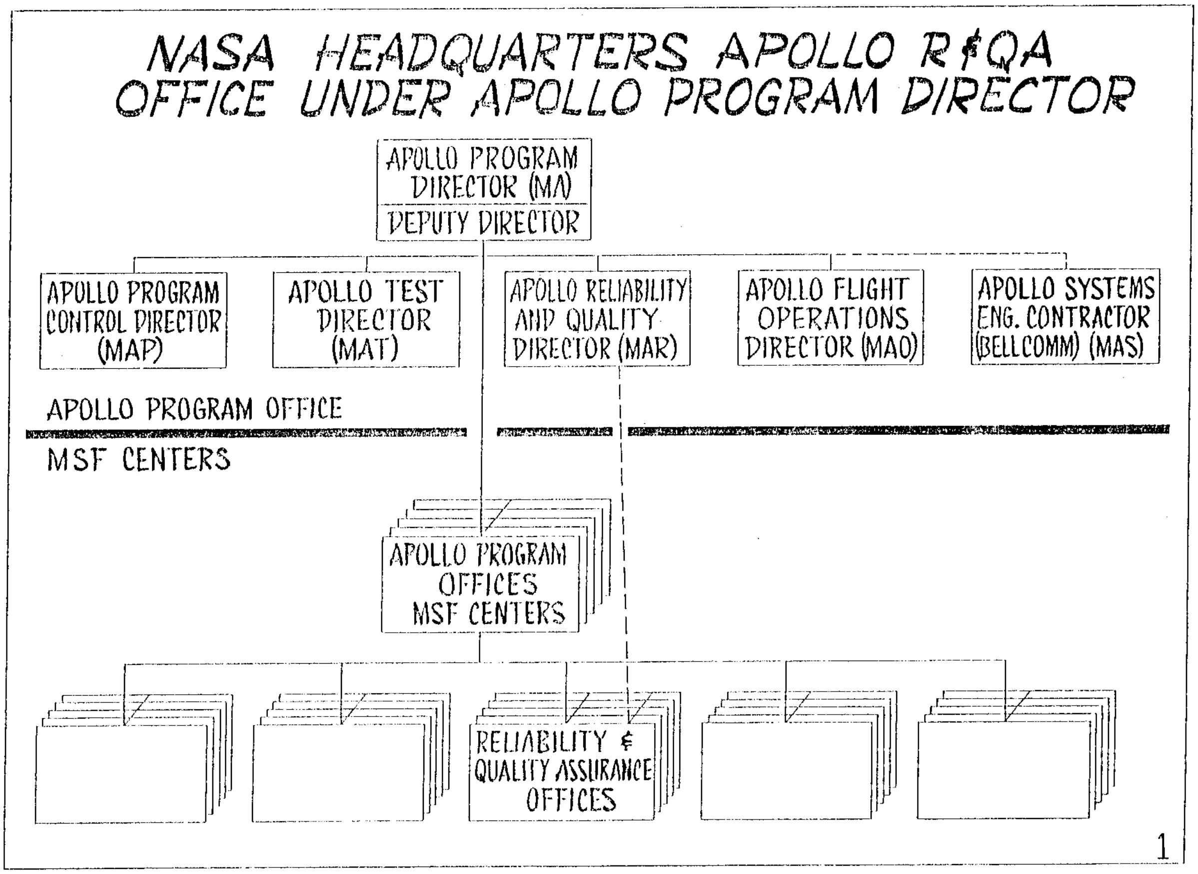
The ALERT System proved to be an effective way to share defective component data to other NASA Centers and contractors. The ALERT system also proved to be an effective element of R&QA through the rest of the Redstone/Jupiter programs and into the Saturn Project. Each KSC technical directorate treated ALERT notices in their own manner.

By 1964, the Kennedy Space Center management was assigning R&QA duties to each Center Directorate. They were to work under their own management, but also under the Project Director, or the Apollo R&QA Office for guidelines promulgated by NASA Headquarters.

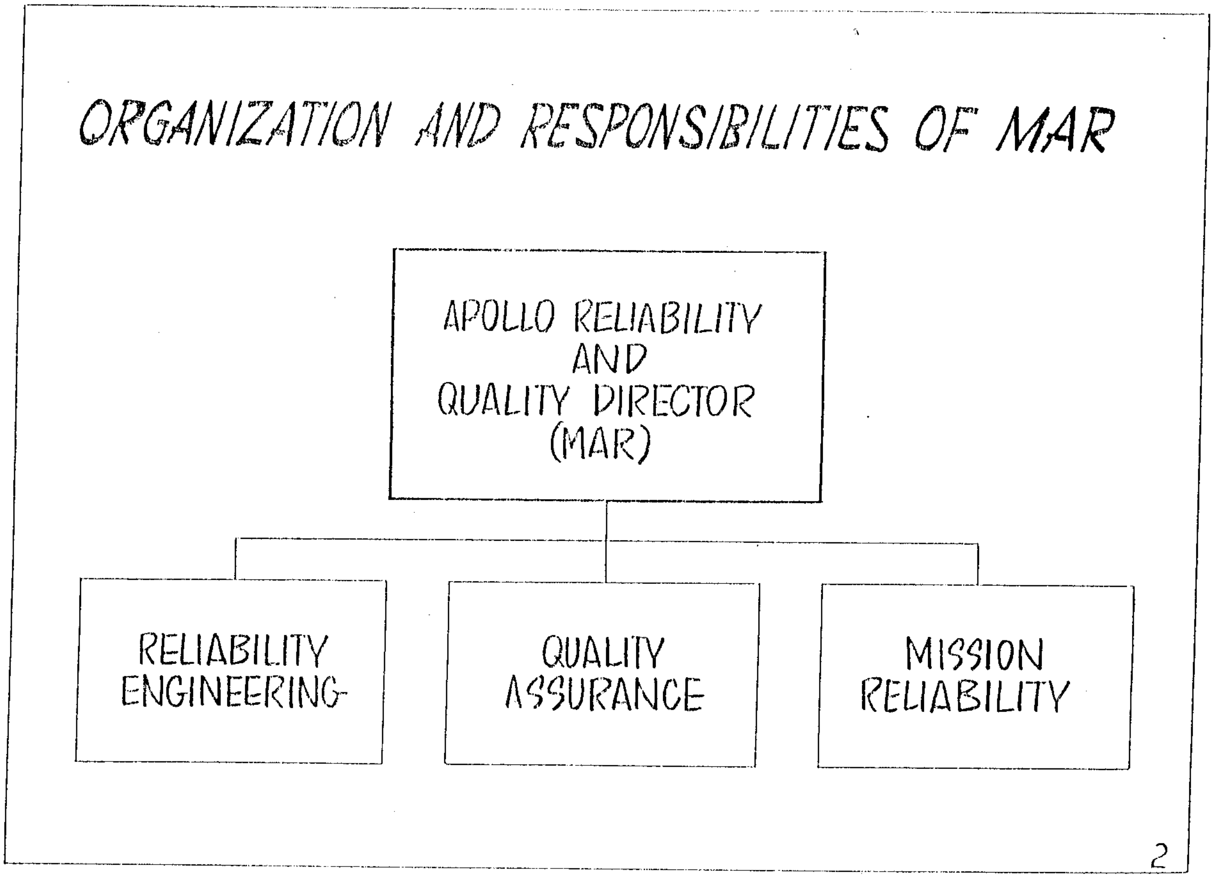
NASA was being noticed more and more by private industry and by the educational institutes as a place where high technology was taking place. They wanted more information on any progress being made in space technology and operations. Because of shortage of Public Affairs personnel, the author was asked to give a presentation on KSC's R&QA progress to graduate students of the University of Miami on July 23, 1965. The presenter ended the session with the following message from Dr. Kurt Debus, the first Center Director of the Kennedy Space Center.

> "Let us proceed to even more challenging tasks which lie ahead with renewed enthusiasm and confidence. We must always be mindful that what we do here will affect the destiny of the nation and of our children for generations to come."

The following flip charts, provided by the KSC Apollo R&QA office were used in the presentation to show operational responsibilities at the time:



Flip Chart #1 - NASA Headquarters Apollo R&QA Office (MAR). Under the Apollo Program Director.



Flip Chart #2 - Organization and Responsibilities of MAR

RELIABILITY ENGINEERING

- RELIABILITY ENGINEERING POLICIES, REQUIREMENTS, STANDARDS AND PROCEDURES
- RELIABILITY PROGRAM PLANS
- RELIABILITY TEST PLANS
- RELIABILITY ENGINEERING TRAINING PROGRAMS
- RELIABILITY ENGINEERING STATUS AND TECHNICAL PROBLEMS ASSESSMENT
- RELIABILITY ENGINEERING RESOURCE REQUIREMENTS AND JUSTIFICATION
- RELIABILITY ENGINEERING PRACTICES AND TECHNIQUES AUDITS
- FAILURE EFFECT ANALYSIS
- RELIABILITY STATUS AND TECHNICAL PROBLEMS ASSESSMENT

2A

Flip Chart 2A - Reliability Engineering

QUALITY ASSURANCE

- QUALITY ASSURANCE POLICIES, REQUIREMENTS, STANDARDS AND PROCEDURES
- QUALITY ASSURANCE PROGRAM PLANS
- QUALITY ASSURANCE TRAINING PROGRAMS
- QUALITY ASSURANCE STATUS AND TECHNICAL PROBLEMS ASSESSMENT
- QUALITY ASSURANCE PRACTICES AND TECHNIQUES AUDITS
- QUALITY ASSURANCE RESOURCE REQUIREMENTS AND JUSTIFICATION

2B

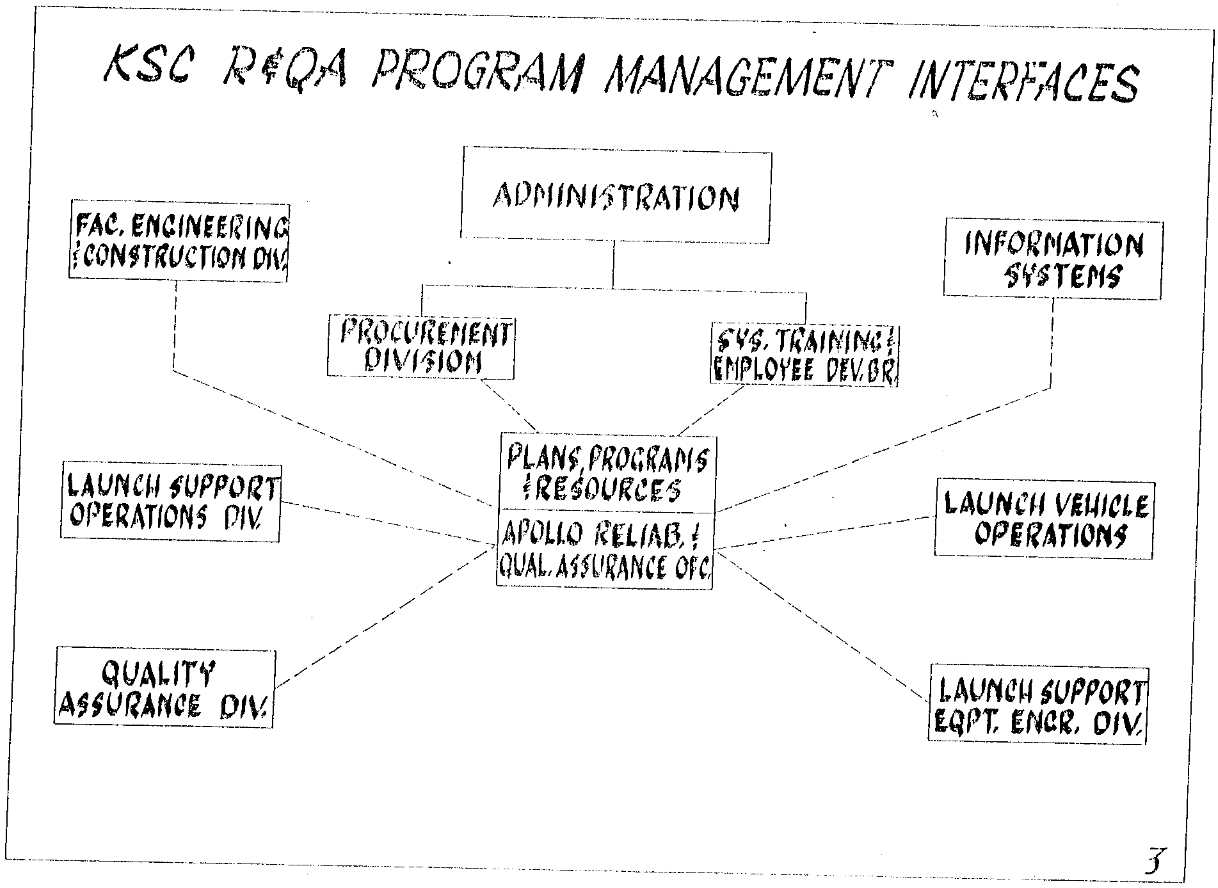
Flip Chart 2B - Quality Assurance

MISSION RELIABILITY

- MISSION SUCCESS AND SAFETY REQUIREMENTS
- MISSION RELIABILITY POLICIES, STANDARDS AND PROCEDURES
- MISSION RELIABILITY MATHEMATIC MODELS
- "STANDARD" MISSION PROFILE
- MISSION RELIABILITY APPORTIONMENT
- MISSION RELIABILITY TRAINING PROGRAM
- RELIABILITY PRACTICES AND TECHNIQUES AUDITS
- MISSION RELIABILITY RESOURCE REQUIREMENTS AND JUSTIFICATION

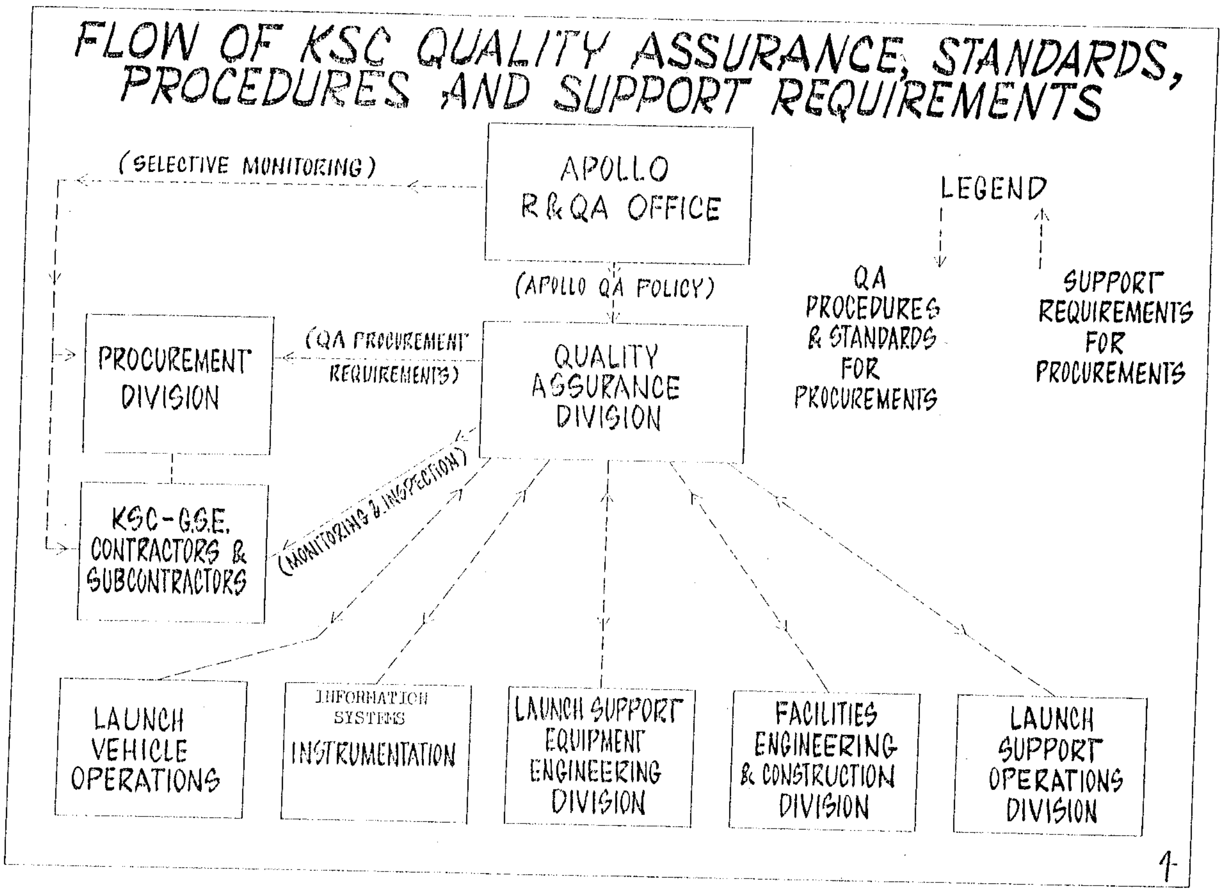
2C

Flip Chart 2C - Mission Reliability



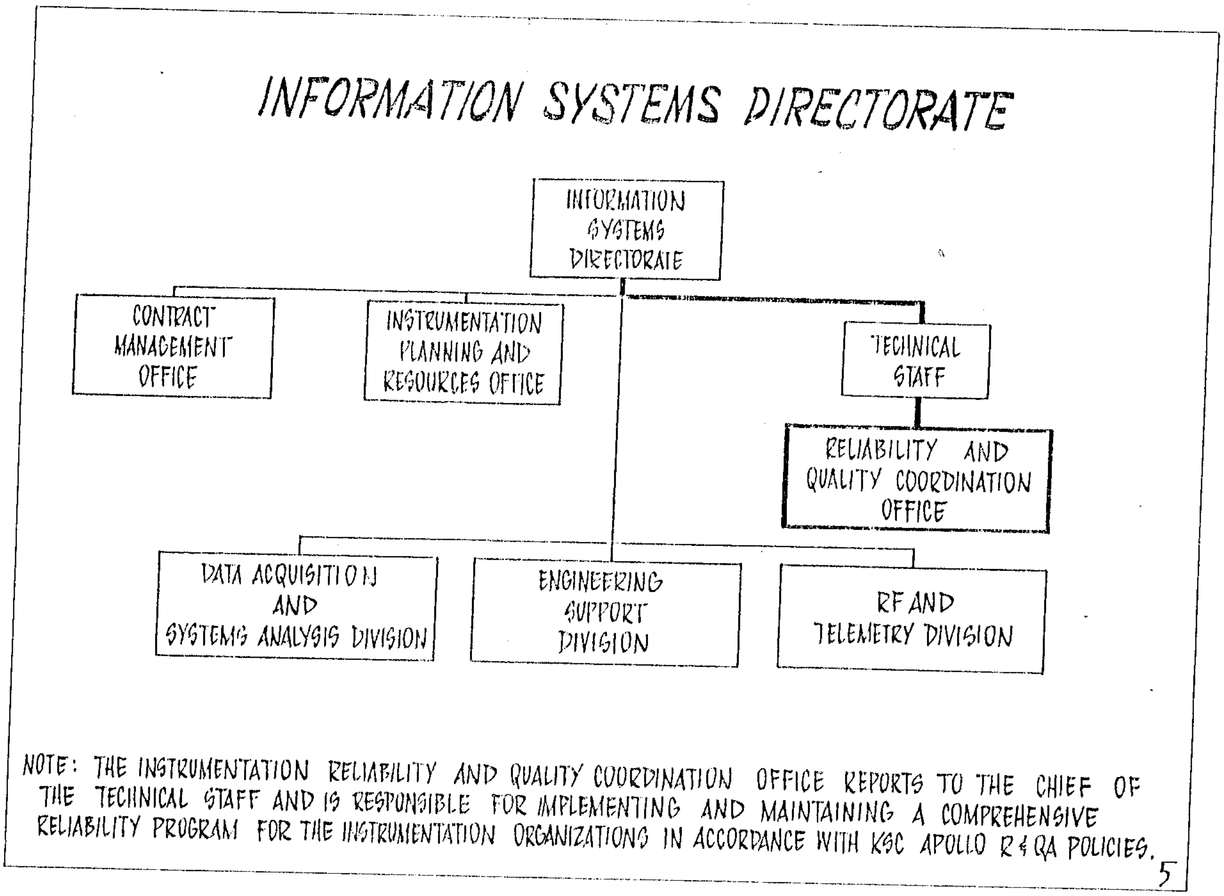
Flip Chart #3 - KSC R&QA Program Management Interfaces

The KSC Apollo Reliability and Quality Assurance Office interfaced with NASA Headquarters for KSC Apollo Program R&QA matters. This office established, defined, and coordinated KSC Apollo Program R&QA policy and management outside Spacecraft Operations. The office also interpreted and assured NASA Headquarters policy, and assured compatibility among KSC organizations concerned with reliability and quality assurance.



Flip Chart #4 - Flow of KSC Quality Assurance, Standards, procedures, and Support Requirements.

The task of implementing the KSC reliability program rested with the various operating Directorates and Divisions as shown in the Flip chart #4. This chart shows the flow of KSC R&QA Standards, Procedures, and Support Requirements.



Flip Chart #5 - Information Systems Directorate Reliability and Quality Coordination Office

Information System's particular responsibilities were carried out under the direction of the Chief of the Information Systems Technical Staff as shown on Flip Chart #5. Mr. Dan Collins was Chief of the R&QA Coordination Office. Mr. Robert Body succeeded Collins, then Mr. John Fike continued as Chief of the Information Systems Directorate R&QA Surveillance Office well into the Space Shuttle era.

One of the most important organizations was Launch Vehicle Operations (LVO). This organization gave close support during vehicle handling, fueling and day-to-day operations. The QA Division's responsibilities below are taken from page 6 of the May 25, 1967, copy of the Spaceport News:

> "KSC'S Quality Surveillance Division of Launch Vehicle Operations aim for perfection and approaches it according to Don Oswald, division chief.
>
> Oswald speaks for an organization that was formed in July 1966 by KSC under his guidance, to supervise the quality and reliability of the updated Saturn and Saturn V programs.
>
> 'We try to make sure all equipment is as close to perfection as humanly possible by inspecting on a 100 percent basis all modifications and engineering changes incorporated into the vehicle and associated launch support equipment,' said Oswald, 'and by continually inspecting the vehicle stages, the ground support and the electrical support equipment for defects and deficiencies of any nature. Our effort is to get the launch vehicle perfect.'
>
> Findings during inspection have not only corrected malfunctions in hardware, but in addition, the records from these inspections are used to evaluate the performance of the contractors' reliability and quality assurance efforts.
>
> Oswald's division also reviews and approves the stage contractors' quality and reliability program plans under the KSC contracts. Besides, the division performs survey and quality reviews of the contractor's quality control operations.
>
> The division, originally staffed 66 inspectors from various KSC engineering sections, now has approximately 90 employees distributed among launch complexes 39, 34 and 37.
>
> The first 66, all having been involved in Saturn programs as technicians, were converted to inspectors and were given a training program by NASA to teach them reliability and quality control functions.
>
> The division prepares many quality control procedures for the instruction of their reliability and quality assurance personnel and technical instructions that affect contractors as well as launch vehicle operations personnel.
>
> The success of the Surveillance Division is due in part to the supervisors. The top five have over 100 years experience in civil service and over 80 years in reliability and quality control work.
>
> They are Oswald, M.H. Camomilli, Deputy Division Chief; George Senical, Branch Chief of Updated Saturn Quality Surveillance; Robert Abbott, Branch Chief of Saturn V Quality Surveillance; and Wayne Priddy, Chief of the Reliability Staff.
>
> The KSC branch maintains a close working relationship with the Marshall Space Flight Center's quality control organization to maintain continuity of quality from inception of the hardware to launch." (17)

Chart #4 also shows the importance of another key organization who reported just how that office conducted business at KSC during the Apollo Program. Robert A. McDaris headed up that office and played a major role in the overall implementation of quality assurance across the Center. His own account of that major effort follows from page 3 of the August 31, 1967, SPACEPORT NEWS:

"KSC'S Quality Assurance Division is a staff function responsible for establishing Center-wide plans and policy in quality assurance and implementation of these programs in the field.

As Director Robert A. McDaris explains it, each major Center element either has its own quality assurance organization, or is serviced by one.

'Look at it this way,' McDaris says. 'KSC can be compared to a corporate structure with each major directorate representing a company within that structure. Each director is responsible for management of one or more major mission support contractors and one of his most important "tools" for effective management is his quality assurance organization.'

'It's our job, as a corporate staff office, to see that all directorates follow the overall KSC plan for quality assurance, and advise the Center Director accordingly.' To carry out this part of the program, McDaris has split his small work force into two offices: Plans and Policy under Andy Mayse, and Audits and Status , headed by Joe Mayer.

When we started,' McDaris recalls, 'there were very few published guidelines for a Center-wide quality assurance program. Our Plans and Policy Office has since published 15 documents in specialized areas of Reliability and Quality Assurance..

These serve as policy 'ground rules' for the various directorates to follow. Mayer's Audit and Status Office then makes periodic checks in the field to insure that the quality assurance programs are being carried out in accordance with Center policies.

Though McDaris' staff is small, he says there are several hundred civil service and contractor employees working in the reliability and quality assurance field at the Center.

'Contractors have their own quality people;' he says, 'but since NASA has mission responsibilities, it becomes a KSC function to provide effective management over the contractor's quality assurance program.'

Joe Bobik's people do this in Spacecraft Operations, for instance, checking contractor quality work on the Command and Service Module, and Lunar Module, among other things. Launch Vehicle Operations, under Don Oswald, has similar responsibilities for all Saturn stages.

It is McDaris' job, in simplest terms, to obtain an overall consistency and uniformity of Quality Assurance throughout KSC.

More specifically, the objective is to 'provide for the consistent application of NASA quality assurance philosophies and practices, and to ensure that the quality levels of all facilities, hardware, software, and services used by

KSC fulfill the requirements of which they are part, or which they support.

There are, at present, seven KSC Directorates with quality assurance line organizations of their own. They are:

1. Launch Vehicle Operations, Quality Surveillance Division, D.R. Oswald, Chief.
2. Spacecraft Operations, Quality Surveillance Division, J.M. Bobik, Chief.
3. Unmanned Launch Operations, Operations Support Branch (R&QA), W. Brinkley, Chief.
4. Design Engineering, Technical Staff, Otto Fedor, Chief.
5. Information Systems, Quality Surveillance Office, D.D. Collins, Chief.
6. Support Operations, Quality Surveillance Office, Dr. J.B. Gayle, Chief.
7. Installation Support, Quality Engineering and Control Division, R.A. Gramer, Chief.

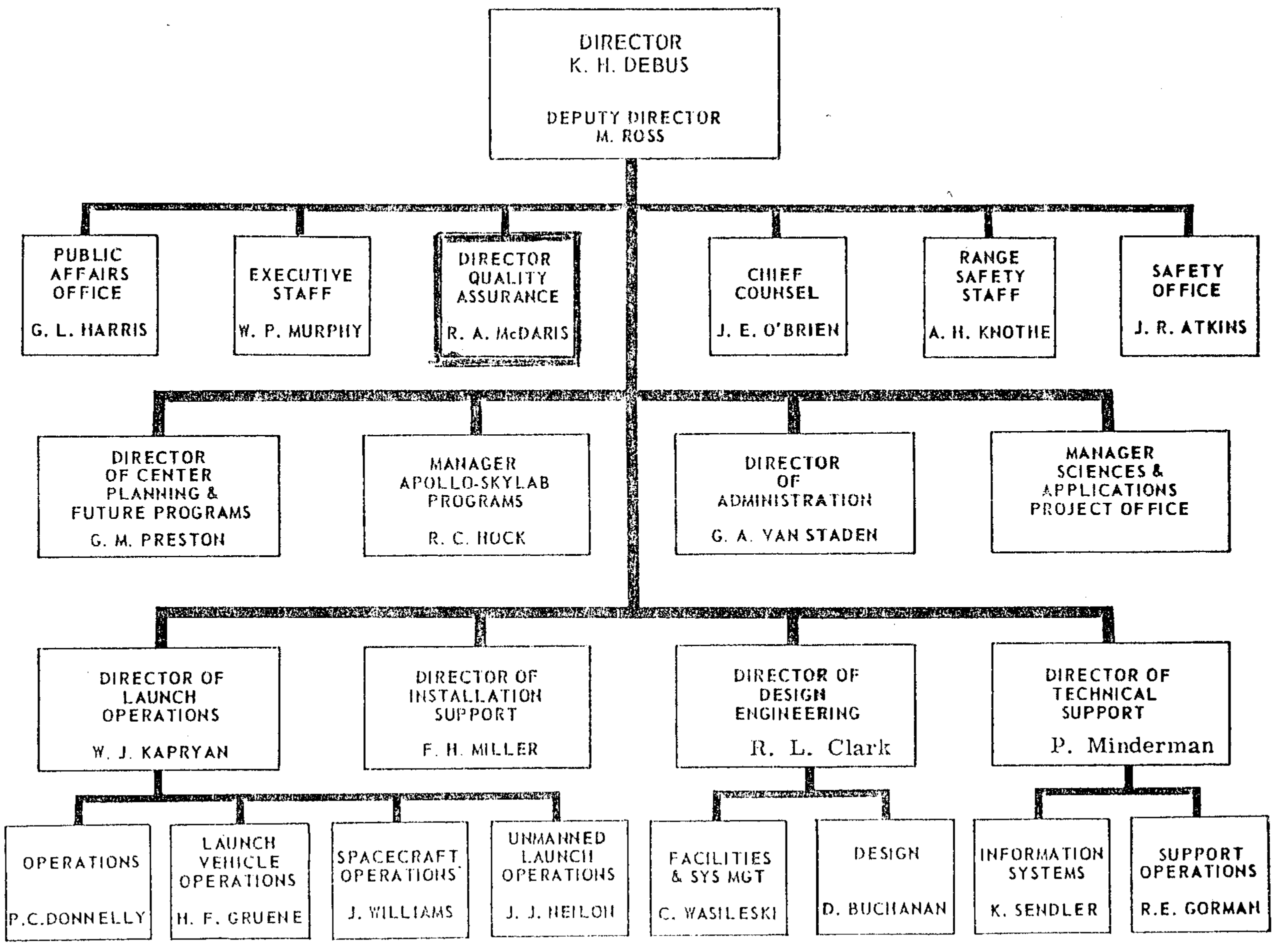
Additionally, there are three program and project managers with responsibilities for developing and establishing their requirements for inclusion in the KSC Quality Assurance Programs. They are: Apollo Program Manager, Apollo Applications Program Manager and a manager for unmanned projects, to be performed by ULO. R. L. Body is Chief of the Apollo Applications Reliability and Quality Assurance Offices.

McDaris said KSC is aided in the implementation of its quality assurance policies by the Air Force Test Site Office. This group which acquired valuable experience in the Gemini program, helps in the Unmanned Launch Operations and receipt of Center-procured hardware.

As a staff office, my own people have no line direction authority. We can, therefore, better channel our efforts toward the development and use of Center quality assurance policies." (18).

The following KSC Organization Chart depicts the Director of KSC Quality Assurance reporting to the KSC Director, Dr. Kurt Debus. Mr. R.A. McDaris was the Director of KSC Quality Assurance across the Center. He co-located his Quality Engineers to give support in procurement quality requirements and surveillance of off-site contractors who provided hardware and software support for KSC installations and up-grades. He also provided support in all receiving inspection actions for the Center.

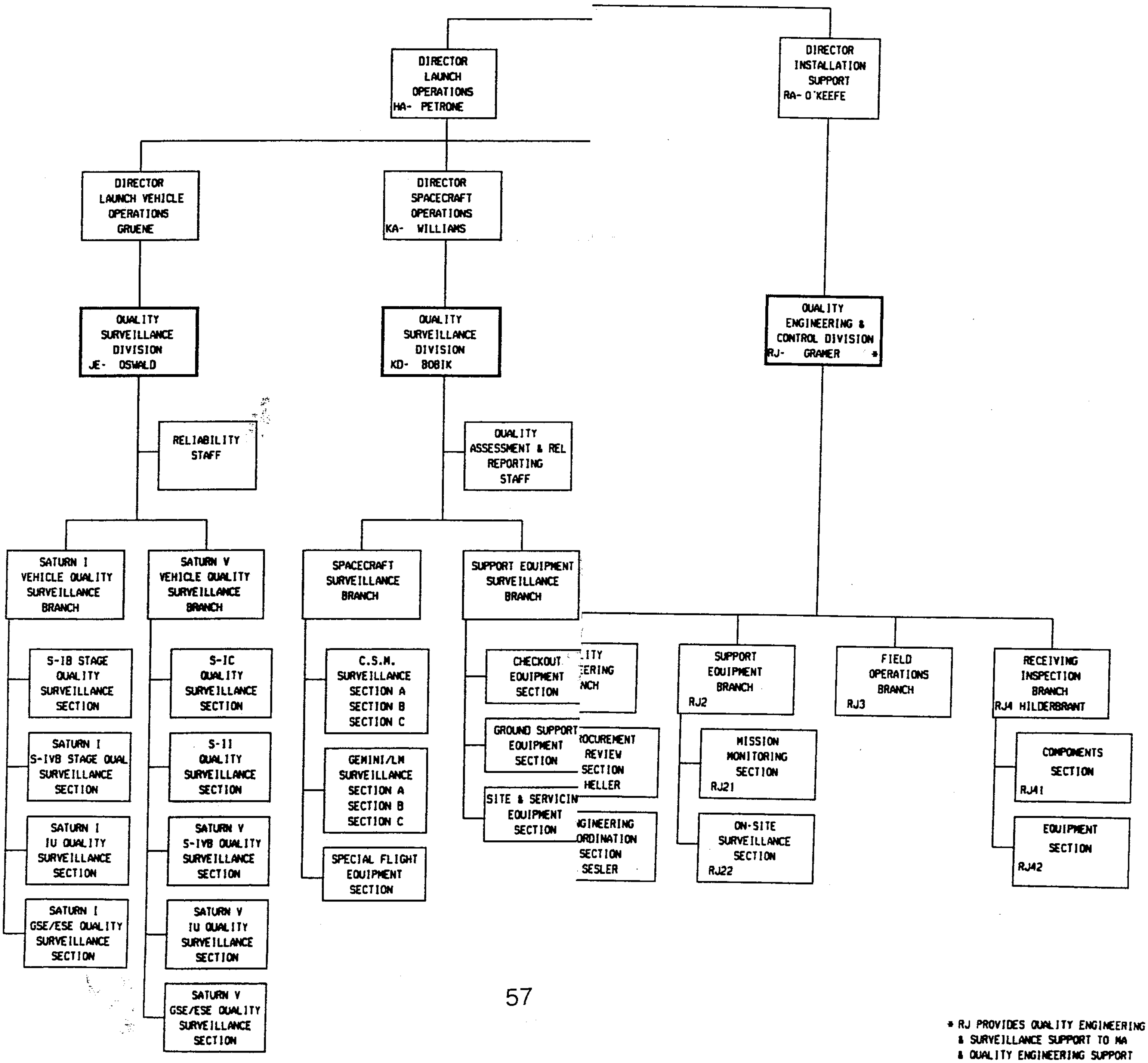
KSC ORGANIZATION



KSC Organization Chart, 1960's Period

The following chart shows the Quality Assurance Inter-organization Relationships during the early Apollo Program. The note at the bottom right of the chart states that the Quality Engineering Directorate and Control Division provided support to the Design Engineering Directorate, and Quality Engineering to all other organizations.

QUALITY



DIRECTOR LAUNCH OPERATIONS HA- PETRONE
DIRECTOR INSTALLATION SUPPORT RA- O'KEEFE
DIRECTOR LAUNCH VEHICLE OPERATIONS GRUENE
DIRECTOR SPACECRAFT OPERATIONS KA- WILLIAMS
QUALITY SURVEILLANCE DIVISION JE- OSWALD
QUALITY SURVEILLANCE DIVISION KD- BOBIK
QUALITY ENGINEERING & CONTROL DIVISION RJ- GRAMER *
RELIABILITY STAFF
QUALITY ASSESSMENT & REL REPORTING STAFF
SATURN I VEHICLE QUALITY SURVEILLANCE BRANCH
SATURN V VEHICLE QUALITY SURVEILLANCE BRANCH
SPACECRAFT SURVEILLANCE BRANCH
SUPPORT EQUIPMENT SURVEILLANCE BRANCH
S-IB STAGE QUALITY SURVEILLANCE SECTION
SATURN I S-IVB STAGE QUAL SURVEILLANCE SECTION
SATURN I IU QUALITY SURVEILLANCE SECTION
SATURN I GSE/ESE QUALITY SURVEILLANCE SECTION
S-IC QUALITY SURVEILLANCE SECTION
S-II QUALITY SURVEILLANCE SECTION
SATURN V S-IVB QUALITY SURVEILLANCE SECTION
SATURN V IU QUALITY SURVEILLANCE SECTION
SATURN V GSE/ESE QUALITY SURVEILLANCE SECTION
C.S.M. SURVEILLANCE SECTION A SECTION B SECTION C
GEMINI/LM SURVEILLANCE SECTION A SECTION B SECTION C
SPECIAL FLIGHT EQUIPMENT SECTION
CHECKOUT EQUIPMENT SECTION
GROUND SUPPORT EQUIPMENT SECTION
SITE & SERVICIN EQUIPMENT SECTION
LITY EERING NCH
ROCUREMENT REVIEW SECTION HELLER
NGINEERING ORDINATION SECTION SESLER
SUPPORT EQUIPMENT BRANCH RJ2
MISSION MONITORING SECTION RJ21
ON-SITE SURVEILLANCE SECTION RJ22
FIELD OPERATIONS BRANCH RJ3
RECEIVING INSPECTION BRANCH RJ4 HILDERBRANT
COMPONENTS SECTION RJ41
EQUIPMENT SECTION RJ42
* RJ PROVIDES QUALITY ENGINEERING & SURVEILLANCE SUPPORT TO HA & QUALITY ENGINEERING SUPPORT TO ALL OTHER ORGANIZATIONS

Each directorate provided their own quality assurance and reliability program office and staff. A Design Engineering Technical Assistant provided reliability oversight of reliability studies and contract provisions under Mr. Fedor as shown on the chart. In this manner, every operations and technical organization carried out a tight R&QA effort with NASA policy direction from the KSC R&QA Office who reported directly to Dr. Kurt Debus, the KSC Director.

Since most of the Apollo support systems were designed and manufactured by industry, it was KSC's responsibility to ensure that adequate, consistent reliability requirements were invoked in the procurement contracts. Each directorate's R&QA personnel participated in the selection of suitable contractors and coordinated with the Quality Assurance Division to ensure that adequate quality requirements were invoked in the contracts for both technical equipment and services.

To assist in the reliability requirements area, the NASA document NPC 250-1, Reliability Program Provisions For Space System Contractors, was followed. Kennedy Management Instructions (KMI's) were issued to cover this function. Four areas were covered in the documents: Program Management, Reliability Engineering, Testing. Reliability Evaluation and Documentation. Reliability Engineering is the area where most effort was required:

1. Design Specifications
2. Reliability Prediction and Estimation
3. Failure Mode, Effect, and Criticality Analysis
4. Unattainability and Elimination of Human-induced Failure
5. Design Review Program
6. Problem Reporting and Corrective Action (PRACA)
7. Standardization of Design Practices
8. Parts and Materials Program
9. Equipment Logs

All of these reliability requirements were considered for each critical launch support instrumentation system. Item #6, Problem Reporting and Corrective Action, and item #9, Equipment Logs were most important in that in establishing life history at the factory, these two elements were a very important reliability data base for the particular system. If any testing or checkout time was expended at the factory, these two elements were very important. The reliability data base for that particular equipment or system began with power-on at the factory and continued through checkout and operation at KSC. Such data was required of the contractor and factored into the reliability program of that system at KSC. Contractors and subcontractors were monitored to assure compliance with KSC reliability requirements by monitoring performance through Quality Assurance and Reliability Program Surveys, Each contractor was visited at least once during the design, manufacture, or test phases. Most of the small contractors did not have a formal reliability organization as such. Much coordination, training and guidance were needed so that a particular contractor could respond to the contract R&QA requirements.

Quality Assurance for the technical Directorates was implemented by the Quality Assurance Division Representatives. To assist in the Quality Assurance Program, NASA published the following documents for use in invoking appropriate requirements into procurement contracts at the NASA Centers. Other implementing documents were added as required as the Apollo Program progressed:

NPC-200-1, Quality Assurance Provisions For Inspection Agencies, April 1961
NPC-200-2, Quality Program Provisions For Space System Contractors, April 1962
NPC-200-3, Inspection System Provisions For Suppliers of Space Materials , Parts, Components, and Services, April 1962.
NPC-200-1A, Quality Assurance Provisions For Government Agencies, June 1964
KMI 5310.11, Nonconformance/Problem Reporting and Corrective Action System
NHB 5300,4(2B), Reliability And Quality Assurance Provisions For Government Agencies, November 1971
NPC-250-1, Reliability Program Provisions For Space System Contractors, July,1963
NPC-200-4, Quality Requirements For Hand Soldering of Electrical Connections, August, 1964
NHB 5300-2, Apollo Metrology Requirements Manual, December 1965
NHB 5330.7, Management of Government Quality Assurance Functions For Supplier Operations, April, 1966
NHB 5300.1A, Apollo Reliability And Quality Assurance Program Plan, July 1966

NHB 5300.3, Handbook for Contamination Control On The Apollo Program, August, 1966
NHB 5300.5, Apollo Applications And Quality Assurance Program Plan, May 1967
NHB 5300.4 (3A), Requirements For Soldered Electrical Connections, May 1968
NHB 5300.6, Apollo Applications Parts And Materials Program Plan, July 1968
NHB 5300.4(1B), Quality Program Provisions For Aeronautical and Space System Contractors
NHB 5300.4(1A), Reliability Program Provisions For Aeronautical And Space System Contractors (Formerly NPC 250-1), April 1970
NHB 5300.4(3C), Line Certification Requirements For Microcircuits, May 1971
NHB 5300.4(3F), Qualified Products Lists Requirements For Microcircuits, June 1972

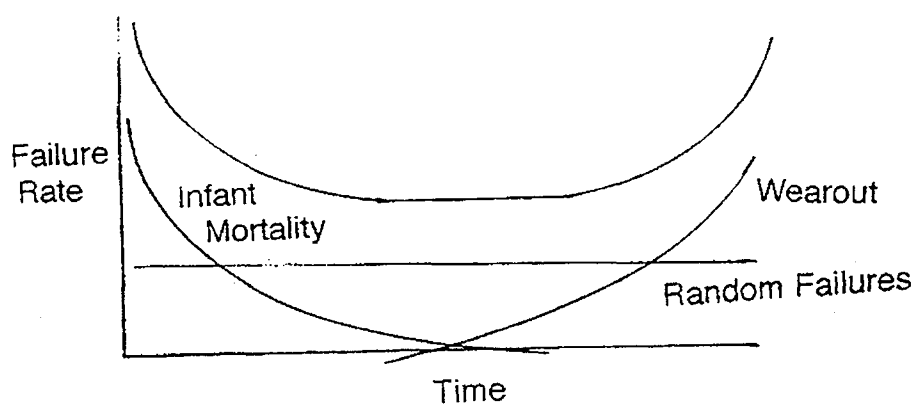
KSC R&QA developed, directed, and performed reliability analysis of launch critical systems; analyses such as Failure Mode and Effects Analysis, Criticality Rankings, Failure Analysis, Alternate Modes of Operation, and Contingency Plans.

A Failure Reporting System was instituted at KSC early in the life of each Apollo support system to report, analyze, correct, and feed back information on all failures or malfunctions recorded. The first reporting form was called the "Unsatisfactory Condition Report (UCR)." This form was completed for each problem occurrence whether it was a minor or a major unsatisfactory condition. This UCR System was used until it was replaced by the Problem Reporting and Corrective Action (PRACA) system. Minor problems historically have been reported on the Discrepancy Report (DR) throughout KSC. Other important problem documentation were, the Open Items List, the Squawk, the Interim Problem Report (IPR), the Constraints List.

Each document was followed up for resolution and correction in a timely manner. Failure reporting is one of the most important tools for reliability determination of an operating system. The Bathtub Curve is widely used to show where the system stands in its failure record. The first section is usually called the region of "infant mortality." This region is characterized by a sharply decreasing failure rate. The failures in this region are usually due to serious defects introduced during the manufacturing process.

The second region is one in which the failure rate is relatively constant. This is called the "useful life" region, and it is popular with probabilistic reliability professionals, because being constant, it can be used to predict failure rate. A common term for expressing a constant failure rate is mean-time-between-failures (MTBF). The failure distribution in this region is also the sum of a series of smaller failure distributions. In most cases, random events are assumed to dominate this region, and failures here are often called "extrinsic" because they result from events external to the item or system.

The third region is characterized by an increasing failure rate, and is called "wart." This is the region in which a major failure mechanism progresses to the point where it causes failure of all remaining items or subsystems. The "bathtub" curve shown below shows the sum of the infant mortality, random failure, and wart curves:



Bathtub Reliability Curve

NASA Headquarters established the Parts Reliability Information Center at Marshall Space Flight Center as the official parts information data bank for all of NASA. KSC was tasked to supply reliability data to the data bank as failure history was developed. Each critical work station was required to keep an equipment log for recording all failures and corrective action on launch essential systems. Such information allowed reliability personnel to determine these reliability elements: non-perfect repair, operating time, down time, meantime to failure, meantime between failures, meantime to repair, and configuration changes to the system being logged.

In spite of good R&QA requirements invoked in hardware and services contracts, many costly mistakes were made in the Apollo Program. The NASA Safety Newsletter of March 1971 presented the following case studies which were of interest to all who worked on manned space programs:

HUMAN ERROR PRIME CASE STUDIES SPOTLIGHT LESSONS TO BE LEARNED

As NASA moves into its newer programs, it is incumbent on us not to repeat costly mistakes.To discover the specific lessons to be learned from bitter experiences of the past, the NASA Safety Office commissioned a contractor to survey all the prime contractors to obtain summaries of what had happened during the development years of the Apollo space program in the U. S. The results were published in an "Orange Book" officially titled "Manned Space Program Accident/Incident Summaries." The "Orange Book" could be used in training programs.

Of some 10,000 case documents reviewed, 508 mishaps were selected for closer scrutiny. As might have been expected, forty-seven per cent of these accidents occurred during operational test and checkout. Procedural deficiencies constituted the single largest contributor to accidents, forty-six per cent. In addition, seventy-four per cent of the cases involved human error as a contributing factor. Obviously then, many accidents contained several types of errors.

The list which follows skims from the top of the compilation the largest number of mishaps:

Lesson to be Learned	Occurrences
Inadequate Check List	48
Engineering or QC did not verify component installation instructions	41
Hazard analyses not conducted	40
Lack of personnel certification	36
Design deficiencies in equipment	35
Cross-connected cables or fluid lines	32
Test started without approved procedures	24

Inspection of work performed was lacking or inadequate	21
Designate all pressure and propellant tests as hazardous	18
Place protective nets over flight hardware	17
No relief valve or burst disc in closed pressure systems	17
Require QC verification of materials and components before installation	16
At shift changes, provide transfer of information	13
Keep excess people out of hazardous test areas	13
Don't conduct concurrent tests without QC approval	13
Establish a LOX-compatible material list	13
Restrain flex lines at terminations and every 6 feet	12
Supervision was inadequate	12
Reduce pressures prior to removal of parts	10
Require all hoisting equipment to be verified periodically	10
Operator error	10

(19)

Important studies such as these are often filed instead of being put to practical use. The "Orange Book" was given limited distribution to all Centers and prime contractors during the early years of the space program.

At launch complex 34's dedication on June 5, 1961, it was proclaimed as the free world's largest launch facility. Four months later on October 27th, Saturn 1 (SA-1) was launched as the first of four vehicle development launches from LC-34.

Early Saturn-1 vehicles and spacecraft modules required many modifications of equipment and procedures to be worked at Launch Pad-34 prior to launch day. This was true with many of the NASA launch vehicles including the Space Shuttle after arrival at KSC. The North American and Grumman teams at KSC continued to look to their home offices, and indirectly to Houston for guidance as work proceeded at Pad 34 of the SA-1 launches through preparations and testing of the the AS-204 spacecraft module in January 1967. On January 27, 1967, problems developed within the Command Module and a fire broke out in the spacecraft resulting in the loss of three Apollo astronauts.

This old method of quality assurance ended in the aftermath of the LC-34 tragedy. With the support of NASA Headquarters, KSC took firm control of all spacecraft activities. This gave more strength to quality assurance surveillance efforts at LC-34 and LC-37 launch areas.

After much investigation by the Congress Tragedy Review Board, Dr. Debus was asked if he would like to make a short statement for the record. His statement is taken from MOONPORT, pages 398-399:

> "As director of the installation I share the responsibility for this tragic accident and I have given it much thought. It is for me very difficult to find out why we did not think deeply enough or were not very inventive enough to identify this as a very hazardous test.
>
> I have searched in my past for safety criteria that we developed in the early days of guided missile work and I must say that there are some that are subject to intuitive thinking and forward assessment. Some are made by practical experience and involved not only astronauts but the hundreds of people on the pads.....
>
> It is very deplorable but it was the known condition which started from Commander Shepard's flight....from then on we developed a tradition that....considered the possibility of a fire but we had no concept of the possible viciousness of this fire and its speed.
>
> We never knew that the conflagration would go that fast through the spacecraft so that no rescue would essentially help. This was not known. This is the essential cause of the tragedy. Had we known, we would have prepared with an adequate support as humanly possible for egress. " (20)

No Information Systems Directorate R&QA personnel were assigned to LC-34 during the actual checkout and launch of the first few launches at LC-34. Russell Gramer's Quality Assurance Office was asked to cover certain functions. During these early vehicle development launches, the System Engineer had complete responsibility for the proper functioning of his system as Dr. Debus insisted to the R&QA people. This story is told in Chapter 2, page 18, as taken from the Apollo History, MOONPORT. Dr. Debus' confidence was totally upon his tried-and-true launch team. His quote from MOONPORT was: *"This responsibility should not be attenuated by assigning a separate inspection or quality assurance team to check on the System Engineer or compliance to test procedures and test performance..."*

As the buildup of the Apollo Program progressed in the 1962-1968 era, both contractor and NASA civil service R&QA teams grew larger, and more extensive interfaces/relationships in carrying out their functions were necessary. After the Apollo fire, mission essential systems required double inspection and quality stamping on all tests and launches. Spacecraft Operations double-stamped everything. The Saturn launch vehicle and the Apollo spacecraft were the largest and most complex systems ever put into space. Consequently the reliability and quality personnel also grew and organizations had significantly stronger backing and support from Dr. Debus.

Activation of the Saturn-V launch facilities at the Merritt Island Launch Area (MILA) was supported by KSC R&QA personnel in all work areas as progress was made through installation, checkout and launch of Apollo vehicles, and then later for the Skylab and Apollo-Soyuz missions.

The Apollo-Soyuz Test project (ASTP) was provided by the U.S. and Russian agreement concerning cooperation in the exploration and use of outer space. President Nixon and the Soviet Chairman signed the agreement in Moscow on May 24, 1972. This summit accord also pledged both countries to fulfill the NASA-Soviet Academy of Science's agreement in January 1971 for cooperation in space science and application. Among the application programs was the possibility of space rescue for each other's space teams. The ASTP launch was subject to the usual Apollo program R&QA requirements for checkout and launch activities, and were very successful in assuring a successful launch and mission.

Two R&QA activities throughout the Apollo launches were "Integrity Control" and "Nitrogen Purge Verification." Quality inspectors/analysts were to be commended for keeping these two surveillance activities uppermost in mind during preflight tests and launch preparations. Integrity control assured good configuration control and purge verification of all electrical enclosures which lessened the possibility of explosions at the pad.

One very important quality assurance tool was the Walk-Through Inspections performed either by schedule or on random occasions which did not interfere with operations during important tests. It was helpful in assuring the system engineer that his or her system was in a position to support a critical test. It also was helpful in motivating employees to keep all station-set operations in order according to applicable procedures and responsibilities.

Configuration Control during Saturn/Apollo launches was an important function which assured that changes were fully approved and that actions taken were well documented by both the technical workers and Quality Assurance. Configuration Control Boards (Level I, level II, and level III) were established with controlling authority for "dispositioning" (deciding upon or recommending) proposed changes to its documentation, hardware, and software - to the extent that the change did not conflict with requirements, schedules, budgets, etc. established by a higher level Board.

R&QA representatives played an important role in providing quality assurance data from their records, and in providing a paper trail to the final actions taken by the affected technical area, or areas.

During the SKYLAB program, the KSC launch team had little trouble with establishing spacecraft procedures with Houston, since the command and service module differed little with the Apollo counterparts. Coordination with MSFC was another matter. It took about a year for the two agencies to resolve the problem. The launch team ended up conducting the tests required on the pad. That meant that Don Oswald's Quality Assurance inspector stamped all test procedure inspection points along with the Contractor inspector. This proved acceptable for the overall Skylab except the telescope mount. The story of this problem was found in NASA SP-4208, LIVING AND WORKING IN SPACE, A History of Skylab, starting on page 242:

> "A second dispute concerned preflight tests of the telescope mount. Its checkout represented the first time that a manned space flight center was to perform tests at the launch site (previously contractors had done the actual testing), and some misunderstanding was likely. The full extent of the disagreement came to light in December 1970 at a review of telescope mount flight procedures. Gene Cagle, engineering manager for the telescope mount, took immediate exception to the Kennedy position that his group would perform as a contractor. Even had Huntsville been willing to assume the subordinate role--and it was not--Cagle lacked the manpower to meet Kennedy's requirements. The preflight procedures listed 73 forms that the test team would maintain, many of which required several signatures at various levels. Cagle contended that he had barely enough people to do the actual checkout, much less fill out the paper work. He also objected to the requirement for quality assurance. He estimated that it would take 700 men, three times the number he had, to comply with Kennedy's rule that an inspector must verify each testing step. Furthermore he objected to the launch center's applying its philosophy of quality control to a Marshall operation. At

Huntsville, the testing organization assured the quality of its own work.

Kennedy officials turned a deaf ear to Cagle's criticisms. Their procedures embodied wisdom acquired over many years in the launch operations business. The atmosphere at the Cape before a major launch was quite different from the relatively relaxed conditions of checkout at Huntsville. With thousands of people pushing towards the same deadline, a formal system of paper work was essential. Short cuts inevitably brought on bigger problems. Besides, contractors managed to work within the system. Cagle's request for manpower assistance from Kennedy was denied, since it violated the center's checks-and-balances philosophy. Neither side appeared willing to give an inch, and the meeting was temporarily adjourned.

It took nearly a year to bridge the gap. Spacecraft operations helped by lending Cagle some system engineers from its liaison then in Huntsville. That group followed the telescope to Houston and then to the Cape, working as part of Huntsville's test team. Kennedy also agreed to perform quality checks, as Houston was doing for the thermal vacuum tests. Marshall, in turn, attempted to meet Kennedy's other requirements. The actual checkout of the telescope mount went very smoothly: afterward Debus recognized the test team's work with a letter of commendation." (21).

The ASTP launch on July 15, 1975, was the last launch from the MILA pads 39 A and B until the launch of Shuttle Columbia (STS-1) on April 12, 1981 from pad 39A.

Before venturing into the history of the Space Shuttle Program, notice must be taken of that most important Gemini Program which preceeded the full-blown Apollo Program implementation and its successful missions to the Moon. The following FOREWORD portion from the history of the Gemini Program, "On The Shoulders Of Titans," NASA SP-1203 explains that importance:

GEMINI was the intermediate manned space flight program between America's first steps into space with Mercury and the amazing and unprecedented accomplishments achieved during the manned lunar expeditions of Apollo. Because of its position between these two other efforts, Gemini is probably less remembered. Still, it more than had its place in man's progress into this new frontier.

Gemini accomplishments were manifold. They included many firsts: first astronaut-controlled maneuvering in space; first rendezvous in space of one spacecraft with another; first docking of one spacecraft with a propulsive stage and use of that stage to transfer man to high altitude; first traverse of man into the Earth's radiation belts; first extended manned flights of a week or more in duration; first extended stays of man outside his spacecraft; first controlled reentry and precision landing; and many more.

> These achievements were significant in ways one cannot truly evaluate even today, but two things stand out: (1) it was the time when America caught up and surpassed the Soviet Union in manned space flight, and (2) these demonstrations of capability were an absolute prerequisite to the phenomenal Apollo accomplishments then yet to come.
>
> America's first manned space flight program, Mercury, involved a careful buildup of flight duration to slightly beyond one day with accompanying concerns about man's physiological response to weightlessness and other aspects of his safety and well being. In the meantime, the Russian effort had achieved durations of five days, flight of a multiple crew shortly after the Mercury Program had terminated, and the first extravehicular operation by a cosmonaut shortly before the first manned Gemini flight. The question at that time was who would perform the first rendezvous, seen as a very complex operation but absolutely needed for future space endeavors. (22)

As the history of Gemini unfolds in NASA SP-1203, one can see that critical decisions had to be made about spacecraft, about landing possibilities such as the paraglider method that was being tested, and about a the final design and recovery of a Gemini spacecraft. Opposition to the paraglider came from the MSFC's Flight Operations Division under Christopher C. Kraft, Jr., where questions of reliability took second place to the operational problems posed by the paraglider being in the Gemini program. The many delays, budget crunches and poor testing results finally ended in the cancellation of the paraglider concept of spacecraft recovery. Final testing confirmed that the paraglider method would not meet reliability requirements for manned flight.

To meet the goal of the Gemini Program's rendezvous and docking missions, another spacecraft had to be developed, On January 14, 1963, MSC took charge of the Atlas-Agena program, and after many hardware crises and budget crunches, a reliable target vehicle for the Gemini to rendezvous and dock with was accomplished.

No mention of quality assurance was noticed in SP-1203, but the word "Reliability," appeared several times indicating that R&QA surveillance of all hardware, software and qualifying tests were sufficient for manned flight with the Titan-Gemini and Atlas-Agena programs.

Chapter 5

HISTORY OF R&QA IN THE SHUTTLE PROGRAM

The loss of Skylab on July 11, 1979, was a sad day for all of NASA and those of our nation who loved the space program. The new space adventure with the Space Shuttle began in earnest at that point. An early mission was supposed to visit Skylab, strap an especially designed motor assembly to Skylab and boost it to a higher orbit in a planned effort to save it for future visits with the Space Shuttle. The Shuttle was not ready in time to make that visit.

The Space Shuttle was a whole new approach to gaining access to space. To continue the exploration and utilization of space on a permanent basis, a more economical way to reach orbit was urgently needed. This had become apparent well before the end of the Apollo era, and work had already started on a new type of space vehicle. It had to more nearly resemble the airplane, where the reusable orbiter could fly again and again. The goal was that each orbiter be able to withstand at least 100 missions.

The new orbiter required a new philosophy of operations. No longer would a vehicle be prepared for a single flight. In the future, the same vehicles would return again and again to the Kennedy Space Center, to be processed and launched once more.

The Space Shuttle was very different from the Apollo vehicles, and it was far more sophisticated and technically complex. It was designed, tested and built with limited funds. To help keep costs down, our engineers adapted the Apollo launch facilities, rather than building all new ones. The Vehicle Assembly Building (VAB) was converted to handle Shuttle components. The three mobile launchers used for the Saturns were modified to stack and carry the new vehicle, and Pads 39-A and 39-B were given new above-ground configurations to accommodate the new hardware and interfaces.

Some new facilities were mandatory. A three-mile-long landing strip was one of the first constructed. The orbiter landed several times at Edwards Air Force Base in California until the safety of the KSC orbiter landing was established. Once the safety of landing activities was established and the Microwave Scanning Beam Landing System (MSBLS) was installed and thoroughly tested, Kennedy Space Center then became the primary landing site for the Shuttle.

The last Shuttle facilities completed at KSC were the Orbiter Processing Facilities (OPF) near the VAB. Remaining assembly work and modifications to the orbiters are performed in the OPF's prior to transferring to the VAB for assembly with the solid rocket boosters and the external tank. Quality assurance procedures were developed for all major operations within the OPF's and at the VAB.

In December 1972, NASA Headquarters issued NHB 5300.4 (1D). "Safety, Reliability, Maintainability and Quality Assurance For The Space Shuttle Program." This document was built from NHB 1700.1, NASA Safety Manual, Volume 1, NHB 5300.4(1A), and NHB 5300.4(1B). These were proven base-line documents, and their implementation assured a successful transition to Shuttle S,R&QA efforts.

In the Shuttle era, Reliability Engineers assure that Failure Mode and Effect Analysis (FMEA's) are performed on Ground Support Equipment (GSE) which interfaced with flight hardware items at the launch sites to identify hardware items that are critical to the performance and safety of the vehicle and the mission, and to identify items that do not meet design requirements.

The FMEA's began with an identification of the functional units of each system and a determination of the potential modes of failure for each unit. Each possible failure mode is analyzed to determine the resulting performance of the system and to ascertain the worst-case effect that could result from a failure in that mode. These items are categorized according to the worst-case effect of the failure on the GSE being studied.

It is the System Engineer's and/or the Quality Engineer's responsibility to develop the Quality Assurance documents required for each system or work area. This may consist of a large loose-leaf notebook or files, containing the R&QA Program Plan, the attendant quality procedures and instructions for the assigned quality assurance personnel.

QA Specialists make periodic walk-through inspections of his or her quality assurance area('s). Important things they look for during the walk-through inspections are problem reporting (PRACA), equipment logs or station logs, calibration status of test equipment, integrity control/break-of-inspection, job certification if required, and evidence of an orderly and safe work area. Appendix 7 documents the KSC R&QA survey and audit activities which the R&QA Engineers are responsible for.

R&QA Engineers participate in Design Certification Review's (DCR's) and in the Flight Readiness Reviews (FRR's), and they are assigned R&QA positions at the Launch Control Center (LCC) during flight preparation and launches.

Shuttle Columbia, STS-1, arrived in March 1979. A great deal of work remained to be done. Both Kennedy and Johnson Space Centers were very busy for the next 610 days in the OPF. They had to perform remaining assembly work and a series of major modifications. The orbiter then spent 35 days in the VAB and 105 days on Pad A, before finally lifting off on April 12, 1981. All affected NASA and Contractor work was monitored by QA as assigned during the preparation stages.

It was during this period of STS-1 preparation that KSC R&QA learned that "Cannibalization" became an issue, and Quality Assurance was tasked to track the removal of parts from another STS element to fulfill spares requirements in STS-1. This became more common as the Shuttle flights progressed to the extent that this practice was discussed in the" Post-Challenger Evaluation of Space Shuttle Risk Assessment and Management." The following comment was taken from page 65 of that document:

> "By the time of the Challenger accident, "cannibalization" the removal of parts at Kennedy Space Center (KSC) from one operational STS element to fulfill spares requirement in another, had become a prevalent feature of STS Logistics, thus introducing a variety of failure potentials associated with human error. Cannibalization is not evaluated as a producer of potential failure in either the hazard analysis (where it would be most appropriate) or the FMEA." **(23)**

The Risk Assessment and Management document shows that the incidence of cannibalization at KSC was one-third of the Orbiter Line Replaceable Units (LRU's) flown on some missions. A NASA official at KSC told the Committee that the problem of spares had become so acute that, if Shuttle flights had continued uninterrupted, KSC would not have been able to sustain STS operations. With transfer of responsibility for spares to KSC, and with increases in logistics budget, the picture improved. A state-of-the-art spares warehouse was built near the Vehicle Assembly Building (VAB) in 1985, enhancing logistics operations.

The latest of logistics undertakings was recorded in the December 15, 2000 issue of Spaceport News, starting on page 4:

> "Keeping Kennedy Space Center and other Shuttle support centers supplied with parts for the orbiters and ground operations - from huge fuel cells to timely nuts and bolts - is a massive undertaking.
>
> It's no wonder that the Logistics facility, the building that houses administrative support and approximately 140,000 plus spare line items, measures in excess of 472,000 square feet.,
>
> The facility was built in 1985 south of the Vehicle Assembly Building on Contractor Road to consolidate logistics functions near the processing area.
>
> The Logistics facility includes warehouse space, storage platforms, chemical storage area, yard storage and office space.
>
> The value of supplies contained within the warehouse and storage areas at any one time is estimated at about $1 billion.
>
> While some supplies replenished and kept on hand with the facility are manufactured and periodically delivered by vendors, a number of the parts are about 20 years old, as old as the Shuttle program.

A constant stream of parts and other materials are ordered, stored, processed and delivered to the customers. Parts must be inspected, sorted periodically verified and sometimes repaired.

An automated storage and retrieval system speeds processing requests. Damaged or worn items are also processed at the facility, then sent to the vendor or the NASA Shuttle Logistics Depot for repair.

Orders for parts not only come in from KSC, but also from other Shuttle support sites including Dryden Flight Research Center, the Transatlantic Abort Sites and The Boeing Co. plant in Palmdale, Calif. where Columbia is being refurbished.

"Customer service and satisfaction are essential in what we do," said Eddy Walters, manager of Storage and Distribution for United Space Alliance. "We've got about 6,000 to 7,000 different customers - that's anyone who might order something from us."

About 500 KSC team members, primarily United Space Alliance employees work in the facility. About 100 work in the warehouse area and about 400 in the facility's office space.

Employees work in a variety of departments including Processing Operations, Storage and Distribution, Transportation, Procurement, Engineering, Customer Support, Commodity Management and Quality Assurance.

The major processes carried out in the facility include flight spares distribution, receiving, delivery, packaging and crating, kitting and repairable processing.'

So much happens here. It's like a world within a world," said John Kelly, manager, Vehicle Processing Storage area." (24)

The first Shuttle (STS-1) was launched on April 12, 1981. It was a most exciting day for all the people who supported that grand liftoff and flight. That launch was long awaited by the dedicated Shuttle launch team, and the satisfaction of work well done was felt by all in the Launch Control Center (LCC) on that Palm Sunday of April 12, 1981.

Twenty one (21) launches later, on January 28, 1986, the accident of Space Shuttle Challenger, mission 51-L, interrupted for a time one of the most productive space projects of all times. The story of what happened is well documented in the PRESIDENTIAL COMMISSION reports of investigation.The Commission's initial report to the President, dated June 6, 1986, called, REPORT AT A GLANCE, made this observation about the accident:

"The unrelenting pressure to meet the demands of an accelerating flight schedule might have been adequately handled by NASA if it had insisted upon exactingly thorough procedures that were its hallmark during the Apollo program. An extensive and redundant safety program comprising interdependent safety, reliability and quality assurance functions existed during and after the lunar program to discover any potential safety problems. Between that period and 1986, however, the program became ineffective. This loss of effectiveness seriously degraded the checks and balances essential for maintaining flight safety." **(25)**

This clear finding of the Commission was a hall-mark "lesson learned," which instituted a close look at both NASA Headquarters and the operating Centers like Kennedy Space Center. Records show that KSC was not in the communication loop that made the decision to launch, nor were the facts available to KSC elements until after the tragic event. The teleconference was between only Marshall and Thiokol, on that fateful launch day, when the o-ring problem was discussed and a decision was made to launch on that cold day. The Commission called it; "THE SILENT SAFETY PROGRAM."

Further criticism of Kennedy Space Center R&QA was made when the "Safety, Reliability and Quality Assurance Organization Task Team Review Report of September 1986" was issued. It was issued by the Office of the NASA Associate Administrator for Safety, Reliability & Quality Assurance. The KSC portion is shown as follows:

"The Kennedy Space Center has a nominal single point of contact for S,R&QA, located in the Safety, R&QA, and Protective Services Office. The office reports directly to the Center Director. Although there is a nominal single point of contact, the KSC S,R&QA organization is the most decentralized of the Centers visited. Substantial S,R&QA responsibilities reside in three of the five first line directorates. The S,R&QA personnel in these directorates have independent reporting channels through the directorates to the Center Director. Within these three directorates, S,R&QA responsibilities are spread across nine second level directorates, with three each under GM, DE, and CM. The S,R&QA personnel at KSC, however, have the clearest understanding of the distinction between quality assurance and other functions.

The "self-sufficiency" concept for the Shuttle Processing Contract (SPC) and the Base Operations Contract (BOC) have resulted in specific Safety and R&QA organizations in each of the support contractor organizations. The SPC and BOC contractors have assumed the day-to-day responsibilities for Space and Base related activities. The Lockheed Director of S,R&QA for the SPC contract (Lockheed) reports directly to the Lockheed Director of the KSC launch site. The BOC contractor (EG&G) has separate Safety & Protective Services, and Reliability & Quality Assurance organizations, report directly to the EG&G General Manager. In the transition, personnel predominantly changed organizations, leaving in place the long standing inter-personal relationships between the Safety and R&QA work force.

The change to contracted consolidated Space and Base operations has modified the direct civil service involvement and intimate oversight from "hands-on"/supervisory functions to surveillance functions. Lines of responsibilities for S,R&QA within the KSC civil service work force, and as they flow to the contractor are not clear. Responsibility for instrument calibration were found to be particularly confusing, and overlapping capabilities were identified and growing as part of the " self sufficiency" concept.

Staffing, both within the civil service and contractor operations in S,R&QA has declined modestly as a percentage of the work force, dropping from 11.7% and 8.5% respectively in 1970 to 7.9% and 5.9% respectively in 1986. The major impact at this time is under staffing for sustained operations, forcing extensive shift durations of 12 hours and more for extended time periods. Action recommended:

Separate the Protective Services elements from S,R&QA and Protective Services Office.

Consolidate all elements of S,R&QA related to Quality Assurance in the SR&QA office to provide a central focal point.

Consolidate the Systems Safety Engineering and Operational Safety Policies and Procedures in the KSC engineering organization to be responsible for the total processing of the Shuttle and its payload. This organization should also be responsible for the systems safety of the ground installations required to process the shuttle elements and the payloads.

Co-locate appropriate S,R&QA personnel in the operating divisions and in the S,R&QA organizations of the SPC, BOC, and other on-site contractors, as appropriate, to insure adequate penetration in depth of S,R&QA matters. Review the overlapping calibration programs to minimize duplication and divergent procedures and practices.

Strengthen the capability to compile historical data on systems/ subsystems/components requiring replacement, maintenance or repair to improve the ability to establish trends in a timely manner, and provide adequate inputs to the logistics pipeline.

Review permissible overtime for all personnel involved in critical operations. Revise policies to minimize fatigue related incidents and accidents. (26)

The following organization charts show decentralized relationships. Chart 1 is dated September,1976, showing the decentralized organization mentioned above. Chart 2 is dated December,1985, and shows the Safety Office, the Engineering Office, Security Office, and Policy and Compliance Office breakdowns. Then Chart 3, dated July 1986 depicts the decentralized organization mentioned in paragraph 1 of the QA Organization Task Team Review:

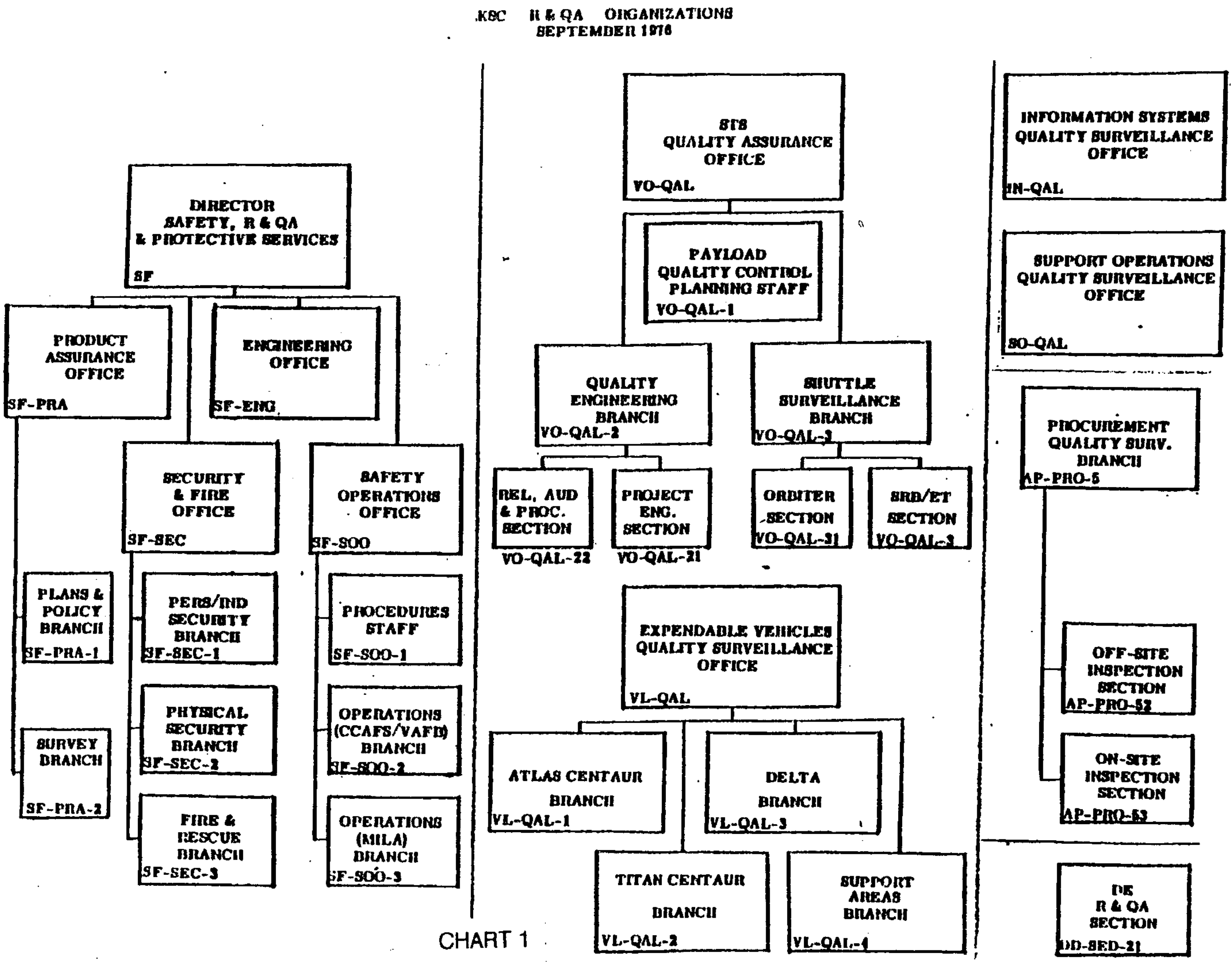


Chart 1, KSC R&QA Organization, September, 1976

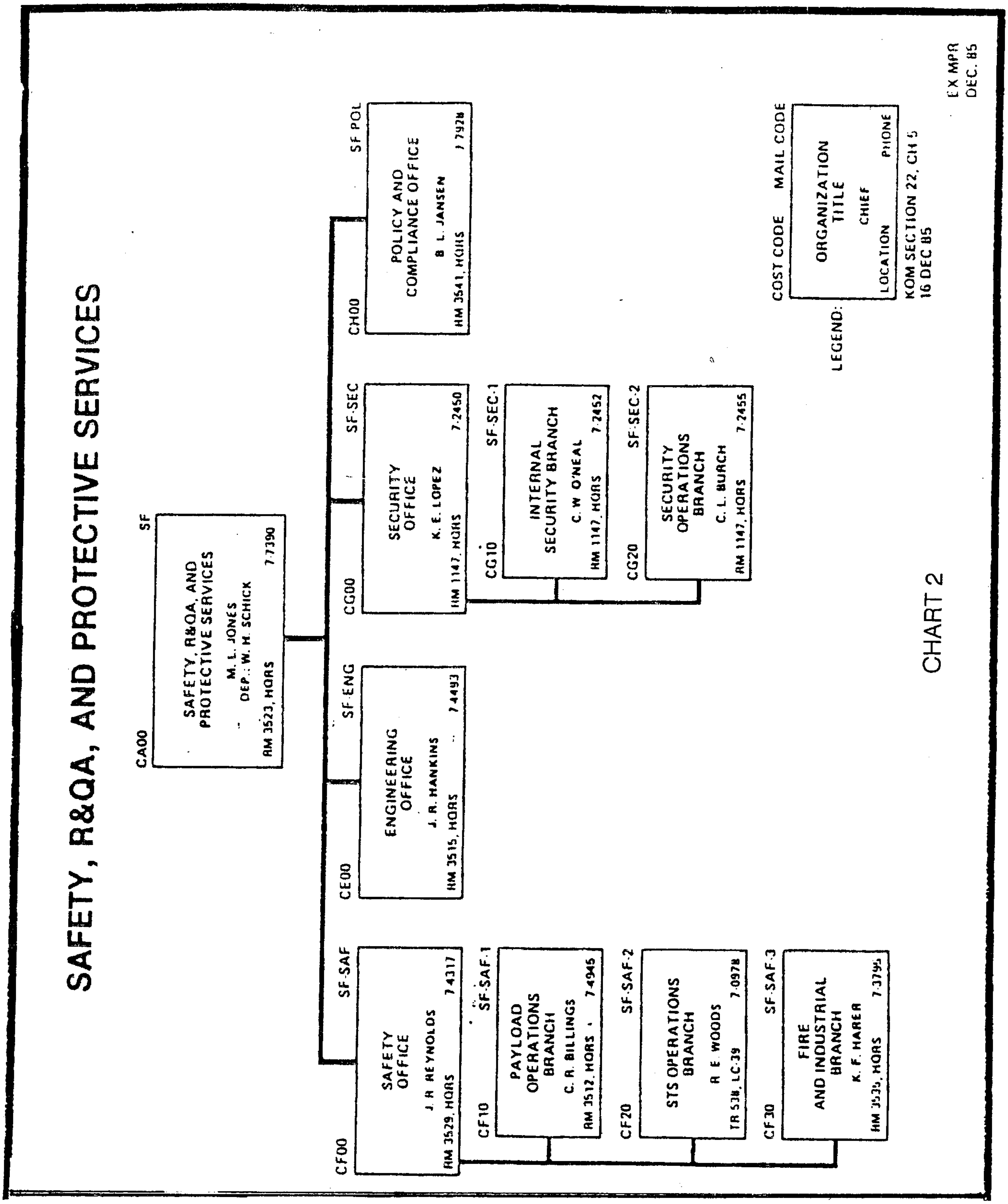


Chart 2, Safety, R&QA, And Protective Services

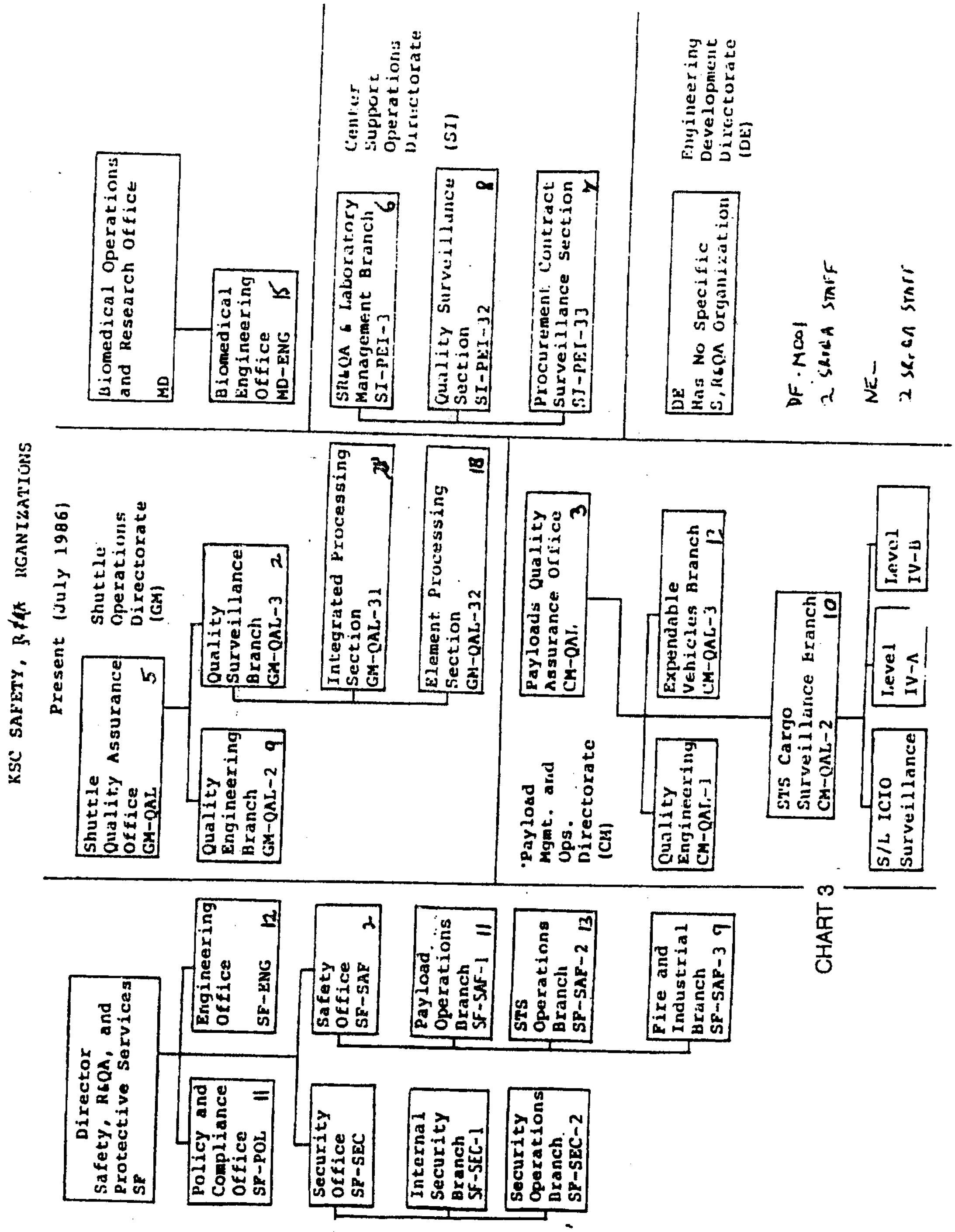


Chart 3, KSC Safety, R&QA Organization,

After the Challenger accident, a PRESIDENTIAL COMMISSION was established to investigate the failed mission. Code Q of NASA Headquarters was highly involved in obtaining answers on many fronts, including the "Silent Safety Program" mentioned on page 73. Here are the questions asked by the Presidential Commission along with answers to each by KSC officials:

<u>KSC INPUTS TO POSSIBLE CONGRESSIONAL QUESTIONS FOR CODE Q RESPONSE</u>

1. What has NASA done to counteract the Presidential Commission's conclusion of "The Silent Safety Program"?

Answer: The NASA Administrator appointed Mr. George A. Rodney to the position of Associate Administrator for Safety, Reliability, and Quality Assurance (S,R&QA) on July 8, 1986. The responsibilities of this office include the oversight of safety, reliability, and quality assurance functions related to all NASA activities and programs and the implementation of a system for anomaly documentation and resolution to include a trend analysis program. One of the first activities underway is an assessment of the resources required, including work force, to ensure adequate execution of the safety organization functions. In addition, the new Associate Administrator will assure appropriate interfaces between the functions of the new safety organization and the Shuttle Safety Panel.

2. What has KSC done in counteracting the commission's report that S,R&QA is under the supervision of the very organizations and activities whose efforts they are to check?

Answer: KSC has established a new organization called the Director of Safety, Reliability and Quality Assurance headed by Mr. James A. (Gene) Thomas. Gene is formally the Director, Launch and Landing Operations for the Space Shuttle Program. He will bring a unique combination of engineering experience in preflight testing and checkout of flight hardware, as well as experience as a Launch Director, to this important new post. The new S,R&QA organization at KSC will centralize safety, reliability, and quality assurance, and will ensure consistent application of standards by certified specialists co-located within the operating Directorates. It will provide an independent assessment of launch readiness and a strong reliability/quality analysis capability. The new Directorate will include the Quality Assurance Offices currently in the Payload, Center Support, and the Shuttle organizations as well as separate functions' for system assurance, reliability, safety, policy and compliance, and quality inspection.

3. What other realignments has KSC made to strengthen operations?

Answer: Thomas E. Utsman, KSC Deputy Director, will take on the additional responsibility for the newly established position of Director of Space Transportation System (STS) Management and Operations through the next few Shuttle flights. In this capacity, he will be responsible for engineering management and technical direction of preflight launch, landing, and recovery activities for Shuttle vehicles. This new organization will provide a single focal point to interface with Headquarters program officials; elevate the Launch Director and Engineering Director, and relieve them of day-to-day operating responsibilities; provide a single Contract Manager, and insure clear channels of communication.

The new Launch Director will be Robert B. Sieck, who will report to the KSC Deputy Director. Mr. Sieck is the former Director of Shuttle Operations. His recent assignment and earlier experience as the first KSC Shuttle Flow Director, and as Director, Launch and Landing Operations, make him the optimum choice for the new assignment. As Launch Director, he will be responsible for the operational management and direction of prelaunch, launch, landing, and recovery for Space Shuttle vehicles.

George T. Sasseen, Jr., will be the Engineering Director in STS Management and Operations. He will be responsible for the engineering management of activities in the new Directorate in support of the Space Transportation System.

Marvin L. Jones, who currently serves as the Director of S,R&QA and Protective Services, will head a new Protective Services Office which will report directly to the KSC Director. The Protective Services Office will plan, manage, and administer vigorous National Resource Protection, over-all security, law enforcement, and the fire and rescue programs under KSC jurisdiction. This emphasis is in line with the increasingly critical need for implementation of the National Resource Protection Plan and KSC's responsibilities for security and protection of the Space Shuttle and its associated equipment and facilities.

4. S,R&QA must have the authority to not only stop a particular flight, e.g.,at a Flight Readiness Review (FRR), but the whole mission. What measures have KSC instituted in this area?

Answer: KSC believes that wherever pressures on the work force are of such a nature that it begins to effect safety, such observations will be made known immediately. These observations will occur many weeks prior to the FRR which is usually held about 10 days prior to launch. Pressures must be surfaced and relieved much earlier than the FRR if adverse mission preparations are to be avoided. S,R&QA has, and always has had, the authority to stop any work on mission planning if safety is jeopardized.

Problems and their solutions are usually discussed at the FRR. However, surprises sometimes surface at this meeting. KSC will not hesitate to inform the new Associate Administrator for Safety of unsolved safety problems that may be presented by other KSC Directorates. However, we will continue to endeavor to solve problems involving safety matters prior to this review. (27)

Item 2 of the "KSC INPUTS TO POSSIBLE CONGRESSIONAL QUESTIONS FOR CODE Q. RESPONSE" explained how KSC was reorganizing S,R&QA after the Challenger accident. Mr. Gene Thomas began his new job as Director of Safety, Reliability, and Quality Assurance, by issuing a brochure as both an incentive and a goal setting thrust for S,R&QA at KSC - Gene's lead-in statement in the brochure is as follows:

"To the NASA Kennedy Space Center Team:

Very few activities in life are ever fulfilling unless we first establish goals to strive for and use as standards to measure our success.

The organizational goals contained in this brochure are the objectives that I would like for us in the RQ Directorate to pursue. Without your dedicated efforts, we cannot be successful. Please review these goals and keep them in mind as we strive to reestablish America as the world leader in Space.

You are the nucleus of our Space Program - the people who really count.

Thank you, signed Gene Thomas."

His Motivational Brochure highlighted the Goal: To establish excellence in the conduct of the Safety, Reliability and Quality Assurance programs at KSC:

- o Through planning and effective management.
- o Assure Safety as our first priority.
- o Produce a quality product.
- o promote job satisfaction.

The Organizational Goals were as follows:

Teamwork, Attitude, Communications (bottom up, top down), Visibility, Involvement, Development, Delegation, Job Enhancements, Personal Initiatives, Rewards, and Sustenance.

The NASA Headquarters Report of the SRM&QA Functional Management Review at the Kennedy Space Center, dated November 4-8, 1991, documents some important findings worthy of including in this history of the KSC's R&QA program. The report not only tells of the findings, but it also gives knowledge of the on-going NASA Headquarters audit function and the Center internal audit tasks in effect in the 1991 era. The Chairperson's Summary follows:

> REPORT OF THE SRM&QA FUNCTIONAL MANAGEMENT REVIEW AT KSC
>
> Chairperson's Summary
>
> This report summarizes the results of a Functional Management Review (FMR) of the Kennedy Space Center (KSC) conducted during November 4-8, 1991. The review focused on safety and quality assurance (QA) disciplines, and consequently was divided into two teams. In comparison to previous Safety and Mission Quality Code Q) surveys, this review focused on assessing the efficiency and effectiveness of the operations, and not just compliance to requirements. Emphasis was placed on identifying areas in management systems where efficiency and effectiveness could be improved. This report describes symptoms of systemic problems and recommends corresponding corrective action.
>
> In the Quality Assurance area, Code Q is planning to reduce the intensity and frequency of compliance surveys of the field centers, if effective internal self-audits are instituted at the field center level. For this reason, the QA Team focused on the KSC internal audit program as well as the KSC audit of their contractors. The QA Team also evaluated the implementation of the Code M Report on Assessment of Human Error Incidents at KSC (The John Young Assessment), dated June 1991, the Problem Reporting and Corrective Action (PRACA) System, and horizontal payloads processing. The Safety Team focused on an assessment of workplace safety, safety performance of site contractors, open findings from previous surveys, and the implementation of KSC requirements, policies, and procedures.
>
> The results of the review indicated that the Safety and Quality Assurance functions are being satisfactorily performed; however, several conditions were noted and recommendations made that would improve the efficiency and effectiveness of the KSC operation. (28)

On May 10, 1992, Mr. Alan J. Parrish, Kennedy Space Center's Safety Reliability and Quality Assurance Director issued a document entitled, "Kennedy Space Center SRM&QA Strategic Ten Year Plan, K-RQ-0001.12, which added "Maintainability" to their title. It was an effort to centralize safety, reliability, maintainability, and quality assurance that would ensure the consistent application of standards by co-locating personnel within the operating Directorates. The idea was to strengthen the role, responsibility, and authority of the four disciplines of Safety, Reliability, Maintainability, and Quality Assurance (SRM&QA). It would enhance NASA's monitoring and oversight capabilities, improve communications and coordination, and provide SRM&QA at KSC with the involvement, authority, and independent check and balance that is essential to maintain the Space Shuttle flight readiness, as well as Payload, Space Station and Base Support Operations.

The background for this change in organization was given on page 1 of the Ten Year Plan as follows:

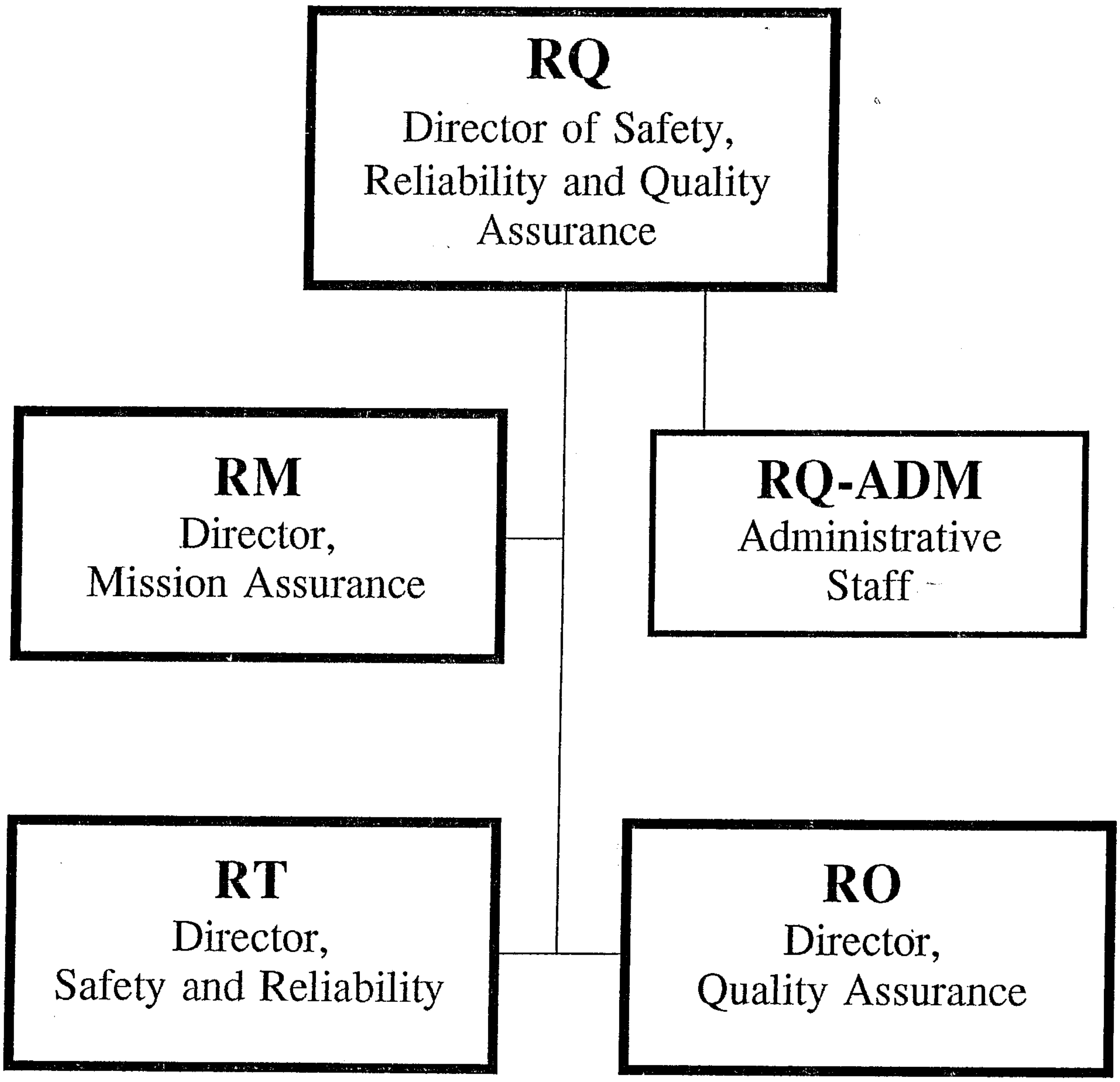
> "Prior to December 1986 at KSC, the Safety program was centralized as a staff function and the Reliability and Quality Assurance (R&QA) Programs were decentralized in the respective line organizations. Since that time, SR&QA has been reorganized and centralized as a line operating directorate under the Director of Safety, Reliability and Quality Assurance (RQ). In 1991, a third second-level Directorate was formed titled the Mission Assurance Directorate. The Director of Safety, Reliability and Quality Assurance now has four organizational elements reporting to him. These elements are designated as the Director, Safety and Reliability (RT), the Director, Quality Assurance (RO), the Director, Mission Assurance (RM), and a staff office called the Administrative Staff (RQ-ADM)." (29)

Beginning in 1986, the centralized SR&QA functions were under the leadership of the following individuals:

Marvin L. Jones
Gene Thomas
Al Parrish
JoAnn Morgan
Tom Breakfield
Chris Fairey

The following chart depicts the (RQ) centralized organization:

SR&QA ORGANIZATIONAL CHART



This KSC SR&QA Directorate was composed of four distinct organizations under the Director of Safety, Reliability, and Quality Assurance as shown in the preceeding chart. The following quote from K-RQ-0001.12, Kennedy Space Center SRM&QA Strategic Ten Year Plan records responsibilities:

> 1. RQ-ADM (Administration Staff) - provides administrative management, advisory services and a centralized administrative support program for the directorate.
> 2. RT (Director, Safety, and Reliability) - manages and directs the safety, reliability, maintainability, and pressure vessel programs at KSC, including performing assessments of safety and reliability engineering analyses, surveillance, audits, and evaluations of safety, reliability, maintainability, and pressure vessels/system (PV/s) certification activities of support contractors and serves as the SR&M Contract Manager Representative (CMR) on selected contracts.
> 3. RO (Director, Quality Assurance - manages and directs the quality assurance program at KSC, including performing surveillance, audits, and evaluations of the quality assurance activities of support contractors and serves as the QA CMR on selected contracts.
> 4. RM (Director, Mission Assurance) - manages and directs the overall independent assessment programs at KSC, including independent technical surveys/audits/ assessments of facilities, systems, flight and Ground Support Equipment (GSE) system processes, engineering analysis of trends, policy and assurance requirements integration and assessment, SRM&QA project management for new programs, progress level assessment of flight and ground systems operational status for Launch Readiness Review (LRR's), Flight Readiness Review (FRR's), and System Requirements Review (SRR's). **(30)**

The Structured Surveillance Program was implemented on November 8, 1993, by issuance of K-RQ-0001.3 by the Director of Quality Assurance (RO), in accordance with requirements of KMI 1050.7, 'KSC Structured Surveillance Program Plan.' The Structured Surveillance Implementation Plan gave guidance for NASA Civil Service to implement the structured surveillance program. The plan identified and provided for more SR&QA interfaces with Program Management, Operations, and System Engineering, as well as internal SR&QA interfaces. Implementing documents provided guidance and standard procedures for SR&QA personnel only and did not attempt to guide Project Management, Operations, or System Engineering in their implementation. The following paragraph is taken from the INTRODUCTION of K-RQ-0001.3:

> "The purpose of this document is to define the NASA Civil service implementation plan of action to implement a NASA Structured Surveillance Program at KSC. Implementation of this plan is expected to increase first-time quality and reduce cost by getting more efficiency into the process which will aid in decreasing the overall process flow time. This will be obtained by relying on the individual performing the task to provide first-time quality. Inspection will be performed on critical items and where risk warrants. Surveillance and sampling will be utilized to improve the efficiency and effectiveness of the process. Process Analysis/Control (PA/C) techniques will be used for areas that exceed surveillance and, or sampling thresholds. The plan will provide requirements, details, processes, and interfaces necessary for the NASA Civil Service work force to meet the requirements of the KSC Structured Surveillance Program Plan." **(31)**

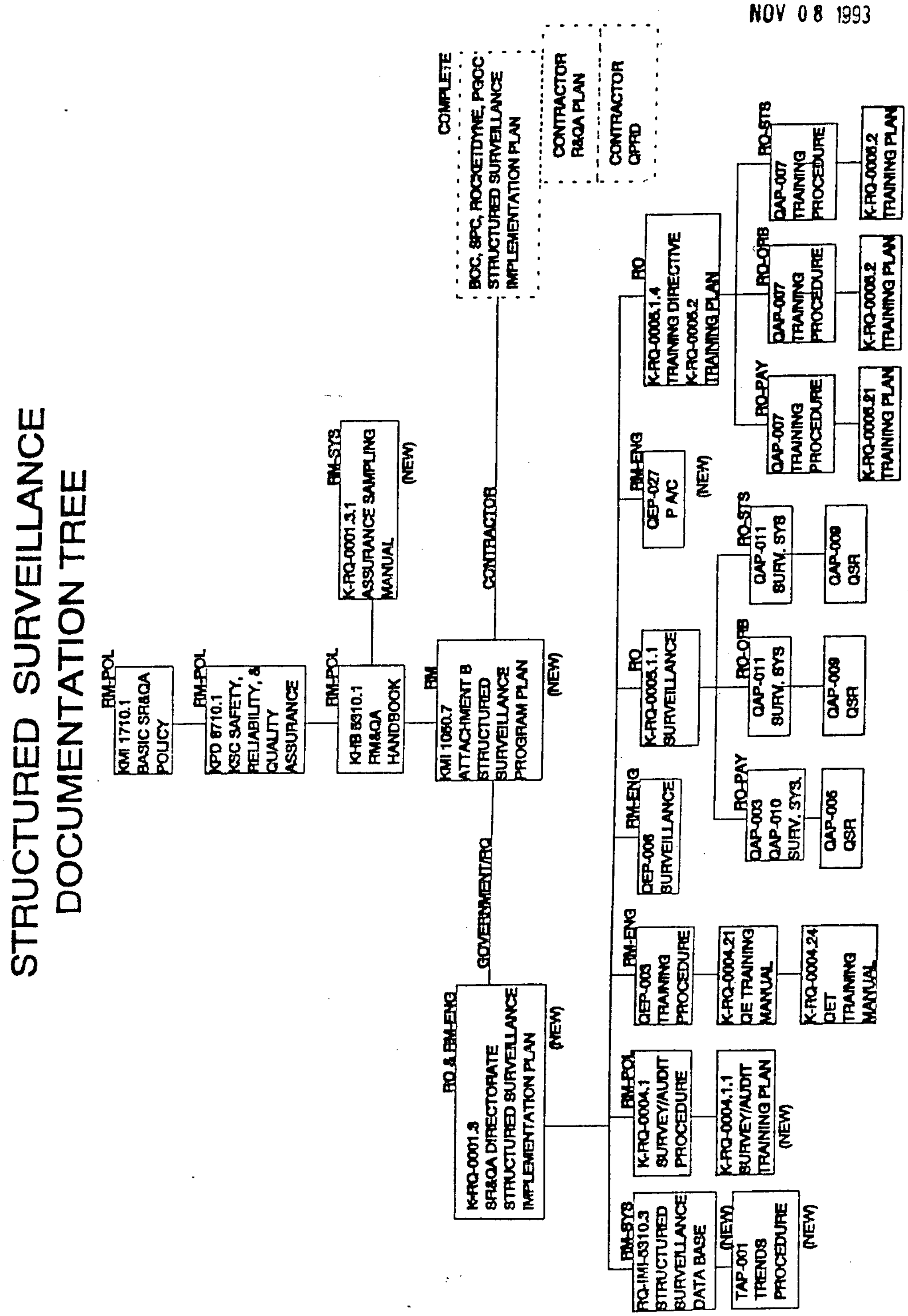
The following KSC documents delineated requirements for the Structured Surveillance Program:

KMI 1050.7,	KSC Structured Surveillance Program Plan
KMI 1710.1,	Safety, Reliability, Maintainability, and Quality Assurance Programs
KPD 8710.1	KSC Safety, Reliability, Maintainability, and Quality Assurance Programs
KHB 5310.1	Reliability, Maintainability, and Quality Assurance Handbook
K-RQ-0001.3.1	Assurance Sampling and Measurement Manual

1.4 The following documents listed below were generated or modified to incorporate the concepts and methodology of the Structured Surveillance Program. The purpose of this approach was to provide maximum flexibility in the organization to cover the program requirements as needed. Each organization would address each reference requirement somewhere within their documentation. Disposition of all requirements were subject to the review process.

K-RQ-0004.1	Safety, Reliability and Quality Assurance Survey and Audit Manual
K-RQ-0004.1.1	Survey and Audit Branch Training Manual (new)
K-RQ-0004.2.1	Quality Engineering Training Manual
K-RQ-0004.2.4	Quality Engineering Technician Training Manual for MRB Signature Authority
K-RQ-0005.1.1	Quality Surveillance System
K-RQ-0005.1.1.4	Quality Assurance Directorate Employee Training and Development
K-RQ-0005.2	Quality Assurance Directorate Training Plan (RO-ORB & RO-STS)
K-RQ-0005.2.1	RO-PAY Training Plan
QAP-003	RO-PAY Surveillance System
QAP-005	RO-PAY Quality Surveillance Record
QAP-007	RO-PAY Personnel Training and Certification
QAP-008	RO-ORB & RO-STS Personnel Training and Certification
QAP-009	RO-ORB & RO-STS Quality Surveillance Record Procedure
QAP-010	RO-PAY Facility and Operations Area Surveillance Procedure
QAP-011	RO-ORB & RO-STS Surveillance System
QAP-003	RM-ENG Training Procedure
QEP-006	RM-ENG Surveillance Procedure
QEP-027	RM-ENG Process Analysis/Control
RQ-IMI-5310-3	Quality Surveillance Record (Structured Surveillance Program User's Guide)

The following chart shows the Structured Surveillance Program documentation tree that was helpful in overall implementation:



The "Vision Statement" of the Kennedy Space Center SRM&QA Strategic Ten Year Plan, R-RQ-0001.12 , page ii, included the goal of promoting proactive assurance techniques to enhance the quality of NASA products, and contributing to meeting the cost/schedule commitments.

"Cost" and "schedule" have been important considerations throughout the American space program, and several approaches have already been touched upon in this history of R&QA. Now one can see a firmer reason to think ahead and plan future R&QA techniques that would accomplish R&QA enhancement within tighter and tighter budget restraints.

The Structured Surveillance Program introduced on November 8, 1993 was part of this R&QA planning NASA introduced in KMI 1050.7, (Structured Surveillance Program Plan) shown on the preceding document tree.

Mr. Raul E. Reyes, Director Quality Assurance, RO remembers his involvement in all the planning and implementation of the proactive assurance technique, called out in the above goal. The McDonnell Douglas Quality Assurance Plan (MDC-Y1159), for the Payload Ground Operations Contract (PGOC), issued in May 1992 proposed the following techniques:

> a. Quality Acceptance Representatives (QARs) temporarily matrixed to the R&QA department to perform reliability and quality assurance tasks.
>
> b. Quality Assurance Designated Verifiers (DVs) to be used for specified areas only after defined responsibilities and limitations were reviewed and approved by NASA RQ. Subcontracted areas were assessed on an individual basis with recommendations for DV/QAR designation based on task criticality, efficiency, and NASA RQ approval." **(32)**

At this point in R&QA history (1994), it is important to mention that KSC was employing nine (9) major contractors to carry out its mission at Kennedy Space Center and at Cape Canaveral. SRM&QA responsibilities were taken from the KSC Contractor SRM&QA FY-1994 Operations Plan (MY), page 1:

> I. **Safety, Reliability, Maintainability and Quality Assurance (SRM&QA)**
>
> Safety, Reliability, Maintainability and Quality are disciplines applied to enhance productivity by reducing the probability of mishaps, failures, maintenance burden, and product flaws. The application of the Quality discipline, the Quality Assurance program, is the performance of all actions necessary to assure with reasonable confidence that a process/product will and/or does satisfy established design/contract technical requirements. The Quality Assurance program consists of two main components, Quality Engineering (QE) and Quality Assurance (QA), the "hands-on" floor inspection. QE provides criteria for determining if a product and/or process is acceptable and QA compares the product/process

against this criteria and determines acceptability or unacceptability.

I I. Kennedy Space Center (KSC) SRM&QA

o NASA: The Safety, Reliability, and Quality Assurance Directorate (RQ) responsibilities include ensuring appropriate SRM&QA requirements are imposed at KSC and assuring compliance with SRM&QA requirements. The QA function provides witness/verification (the "hands-on" floor inspection), based on high risk and/or the product/process criticality, of tasks performed by NASA and KSC contractor technical personnel to determine acceptability or unacceptability. The RQ Directorate is currently manned at 371 with 189 being Quality Assurance ("hands-on" floor inspectors).

o Contractor: The SRM&QA function within the KSC contractor's organizations is responsible for ensuring compliance with the SRM&QA requirements set forth in their contract. The QA function provides witness/verification, based on established contract/product/process SRM&QA requirements, of tasks performed by technical personnel under the same contract, including subcontracts, to determine acceptability or unacceptability. (33)

NOTE: Nine major KSC contractors, each with different contract responsibilities, provided products and services in support of the Center's mission.

o Lockheed Space Operations Company (LSOC) and team companies under the Shuttle Processing Contract (SPC) have the primary responsibility for launch and landing site processing of the Space Shuttle. Responsibilities include processing individual vehicle elements (Orbiter, ET, SRM, SSME, etc.), integrating those elements in preparation for launch, performing payload integration and validation activities with the Orbiter, and operating and maintaining assigned facilities and required support equipment.

O McDonnell Douglas Space and Defense Systems (MDS&DS) under the Payload Ground Operations Contract (PGOC) has the primary responsibility for processing of Space Shuttle payloads (Spacelab, Spacehab, SRL-I, etc.). Responsibilities include operation and maintenance of assigned facilities and support equipment and, in support of the International Space Station Alpha (ISSA), design and acquisition of launch site unique GSE and activation and validation of launch site facilities and Government Supplied Equipment (GSE).

o EG&G Florida, Inc. under the Base Operations Contract (BOC) has the primary responsibility for management, operation, maintenance, and engineering for KSC utilities, facilities, specific technical and administrative operations, and health, fire and security services.

o Rockwell International Corp. under the Orbiter Logistics Contract (OLC) is responsible for the operations of the NASA Shuttle Logistics Depot (NSLD), including the maintenance, repair, fabrication, and modification of designated hardware for which the NSLD has been certified for and has been designated as the repair site.

o The Bionetics Corp. under the Life Sciences Support Contract (LSSC) is responsible for life science activities including biomedical and biological support for prelaunch and post landing processing of flight experiments. Activities also include support to and overall conduct of KSC assigned life sciences research, advanced development, and special projects. Various program support is also provided in the operations of institutional and programmatic capabilities in facilities and laboratories for KSC life science programs.

o Harris Space Systems Corporation (HSSC) under the CORE contract is responsible for design and development of the Test Control Monitoring System (TCMS).

o Analex Space Systems, Inc. (ASSI) under the Safety, Reliability and Quality Support Contract (SRQSC) provides reliability, maintainability, and quality support to the RQ Directorate. The SRQSC does not perform a QA function (witness/verify).

o Hernandez Engineering, Inc. (HEI) under the Safety Support Contract (SSC) provides safety support to the RQ Directorate. The SSC does not perform a QA function (witness/verify).

o I-NET, Inc. under the Engineering Support Contract (ESC) provides support to the Engineering Development Directorate. The ESC does not perform a QA function (witness/verify).

III. Major Itinerant Contractors

NASA Design Centers and Space Shuttle Program Level II have the following contractor support at KSC. These personnel, with the exception of USBI, perform an oversight function of the KSC Space Shuttle processing activities to assure compliance with Design Center requirements. The itinerant contractors, with the exception of USBI, do not perform a QA function, the "hands-on" floor inspection.

o Rockwell International under a Johnson Space Center (JSC) contract to support Orbiter processing. (Five QEs and 71 Configuration Management personnel)

o Rocketdyne under Marshall Space Flight Center (MSFC) contract to support Space Shuttle Main Engine processing. (One QE)

o Martin Marietta Manned Space Systems under a MSFC contract to support External Tank processing. (Four Reliability Engineers)

o Thiokol Corp. under a MSFC contract to support Solid Rocket Booster processing. (Five QEs and one Quality Engineering Technician)

o Loral Space Information Systems under a Johnson Space Center (JSC) contract to support Space Shuttle Program Level II activities. (Two Mission Assurance personnel)

o USBI under a MSFC contract to perform post flight processing and refurbishment of Solid Rocket Booster forward and aft assemblies. (Two QEs, 19 QAs, 21 NDE personnel, one Safety, and one Data Systems person)

IV. QA Overlapping Activities

NASA QA performs, based on established requirements, witness/verification of contractor-performed high risk and/or critical tasks which is also witnessed/verified by contractor QA. Contractor QA performs a witness/verification, based on established contract/product/process SRM&QA requirements, of a subcontractor performed task which is also witnessed/verified by subcontractor QA.

Redundancy may appear to occur when an integrated task is accomplished. As an example, when an Orbiter and a Shuttle payload are undergoing an integrated test, the contractor QA responsible for the payload (PGOC) and the contractor QA responsible for the Orbiter interface (SPC) perform the QA function for their responsible area. There may also be a NASA QA participating if the task is designated as high risk and/or critical.

KSC contractors do not perform the QA function on any other KSC contractor unless the other contractor is a subcontractor. Also the two KSC SR&QA support contractors (SSC and SRQSC) do not perform a QA function (witness/verify) on any activity performed by another KSC contractor.

V. Summary

The KSC SRM&QA team is made up of NASA and KSC contractor personnel, each with different product/process/contract responsibilities. The nine major KSC contractors, each with different responsibilities, provide products and services in support of the Center's mission. KSC contractors do not perform the QA function on any other KSC contractor unless the other contractor is a subcontractor.

QA, the "hands-on" floor inspector, compares the product/process against established criteria and determines acceptability or unacceptability. There are redundant QA functions which are accomplished based on high risk and/or criticality. There are also integrated tasks which have numerous QA functions that are not redundant. KSC contractors do not perform the QA function on any other KSC contractor unless the other contractor is a subcontractor. Also the two KSC SR&QA support contractors do not perform a QA function on any activity performed by another KSC contractor.

KSC Structured Surveillance Program

o Description

The main focus of the KSC QA program, currently being replaced by the Structured Surveillance Program, was on critical item verification by inspection to assure defects were identified and screened out at each level of assembly prior to proceeding to the next level of assembly or operation, augmented by some contractor, and civil service qualitative surveillance. The primary responsibility for product quality inspection, normally after work completion, was on the QA organization. Each mandatory inspection was required every time the assembly or operation occurred; sampling was not used.

The Structured Surveillance Program is currently being applied to all major KSC contracts (SPC, PGOC, and BOC) and Civil Service organizations involved in the assurance of quality at the KSC.

The purpose of the program is to decrease the overall process flow time, increase first time quality and reduce cost by getting more efficiency and effectiveness into the processes. The structured surveillance process is a closed loop system providing a mechanism for fostering continuous improvement of the KSC processes/products to yield better first-time quality. The process includes inspection, surveillance, and Process Analysis/Control (PA/C) methods.

The primary objective of the program is to focus engineering, operations and quality efforts toward defect prevention rather than the detection in completed work and screening of the defects from the outgoing product.

The approach of the program is to provide a method to ensure the technicians and engineers performing the tasks feel empowered to do the work and sense management trusts them and will ensure they have the tools (training and qualifications) to discharge their responsibility doing the task and verifying (stamping) that was done correctly.

o Impact

The implementation of the Structured Surveillance Program has reduced Launch Site Space Station Program QA resources requirements, as currently projected; and will reduce flow time due to reduction of holds for inspection/verification and will therefore result in reduced overall cost.

o Risk

The implementation of the Structured Surveillance Program assumes a risk to schedule and cost caused by major defects which could exist and go undetected until later in the flow.

o Safety Assurance

Safety Assurance is the performance of all actions necessary to assure with reasonable confidence that a process/product will be free from chance of injury or loss of personnel, equipment or property.

o Reliability Assurance

Reliability Assurance is the performance of all actions necessary to assure with reasonable confidence that a Process/product will perform its required functions under defined conditions at designated times for specified operating periods.

- o Maintainability Assurance

Maintainability Assurance is the performance of all actions necessary to assure with reasonable confidence that a product may be easily maintained in accordance with prescribed requirements.

- o Software Assurance

Software Assurance is the performance of all actions necessary to assure with reasonable confidence that a process/product will and/or does satisfy established design contract technical requirements.

- o Quality Assurance

Quality Assurance is the performance of all actions necessary to assure with reasonable confidence that a process/product will and/or does satisfy established design/contract technical requirements.

The Quality Engineering (QE) is that portion of the Quality Assurance program which defines technical quality requirements and provides the criteria for assessing conformance.

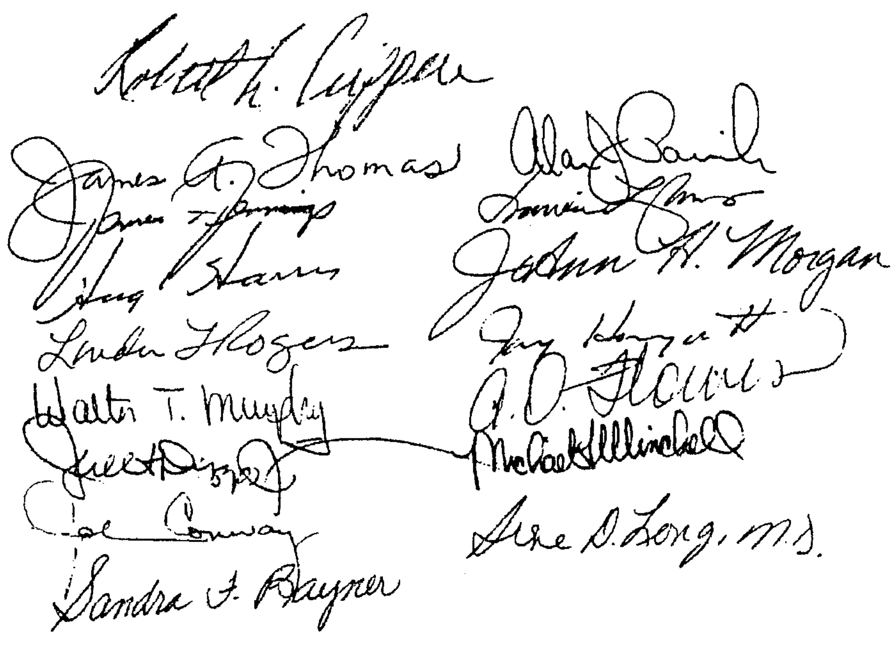
Quality Assurance (QA), at KSC, is that portion of the Quality Assurance program which assesses the implementation of technical quality requirements. Simply put, QE provides criteria for determining if a product and/or process is acceptable and QA compares the product/process against this criteria and determines acceptability or unacceptability. (34)

Also in 1994, the Center was undergoing budget constraints, increasing requirement and heightened sense of urgency that all employees needed to focus on where the Center was going and how KCS planned to get there. Out of these concerns grew a more formal Continual Improvement (CI) program for all employees, top down. The CI planning was carried out under policies within Kennedy Management Instruction (KMI) 1270.2A.

The 1994 KSC Continual Improvement program was developed by the CI Steering Committee appointed by the Center Director. The Center Director, Robert Crippen, and Committee members signed the following document:

The Kennedy Space Center Continual Improvement Plan serves as our road map for achieving quality products and services. CI principles and practices will help us achieve our strategic goals and excel as America's Gateway to the Universe in Preparing and Launching Missions to Earth and Beyond.

Each of us embrace Continual Improvement as the way to achieve success for our organization and the Kennedy Space Center Team.



KSC's Continual Improvement Plan, 1994
(Signature Sheet)

For the Center to achieve success in meeting the strategic goals of CI, each KSC employee involved were required to commit knowledge, skill, and energy to the continual improvement of the tasks, processes, and functions wherever they were employed in their KSC area of responsibility. Responsibilities included the following:

a. Focus on customer needs and expectations
b. Use Customer-driven measures to define quality
c. Communicate requirements to suppliers
d. Achieve initial quality rather than correcting defects
e. Initiate improvement ideas
f. Implement improvements within the organizations
g. Improvement teams
h. Communicate improvements and lessons learned for potential applications elsewhere
i. Acquire and use CI tools and skills in daily work

CI management responsibilities were spelled out in detail and Management Teams were instituted and given guidelines in carrying out their responsibilities. Training and recognition were large parts of the CI program at KSC, and continues throughout the Shuttle and Space Station work areas. The President's Quality Award Program included KSC as a finalist in the 1996 Special Achievement Award for exceptional quality work under budget restraints.

The Safety and Mission Assurance (S&MA Annual Operating Agreement (AOA) For 2002 and Out-years, issued on October 15, 2001 gives more information on Shuttle operations, page 7:

> "The Shuttle Processing Directorate is responsible for overall management, planning, technical direction, and insight of Space Shuttle processing. The Directorate manages all aspects of Space Shuttle processing at KSC, including preflight, launch, landing, and all recovery activities. The organization provides logistics services that ensure flight hardware, ground support equipment, materials, and associated planning are in place to meet all Shuttle processing milestones. The Directorate holds the overall responsibility for safe and reliable execution of Space Shuttle turn around and preparation for launch.
>
> The primary objective of the Safety and Mission Assurance Division within the Space Shuttle Processing Directorate is to ensure that this organization conducts the flight hardware processing operations in a manner that will

achieve mission safety and success. S&MA consists of the Safety, Reliability, Maintainability, Quality, and Software Assurance disciplines that are applied to enhance productivity by reducing the probability of mishaps, failures, maintenance burden, and product flaws. The S&MA Division acts as the S&MA conscience for the Directorate, with a clear voice in NASA and contractor operational and decision making processes. This Division also provides off-site Procurement Quality for other directorates at KSC. (35)

Looking back at the AOA for FY-2000 and Outyears issued in September, 1999, one can notice a vestige of Structured Surveillance. Section 7.0, "GENERAL" on page 5 of that document states:

"The KSC S&MA organization has undergone a significant transformation which is aligned with the strategic goals of the agency, the NASA S&MA organization and KSC. This has required a shift in the way S&MA has viewed their role, and while by no means complete, KSC S&MA is well on the way to implementing these revolutionary changes.

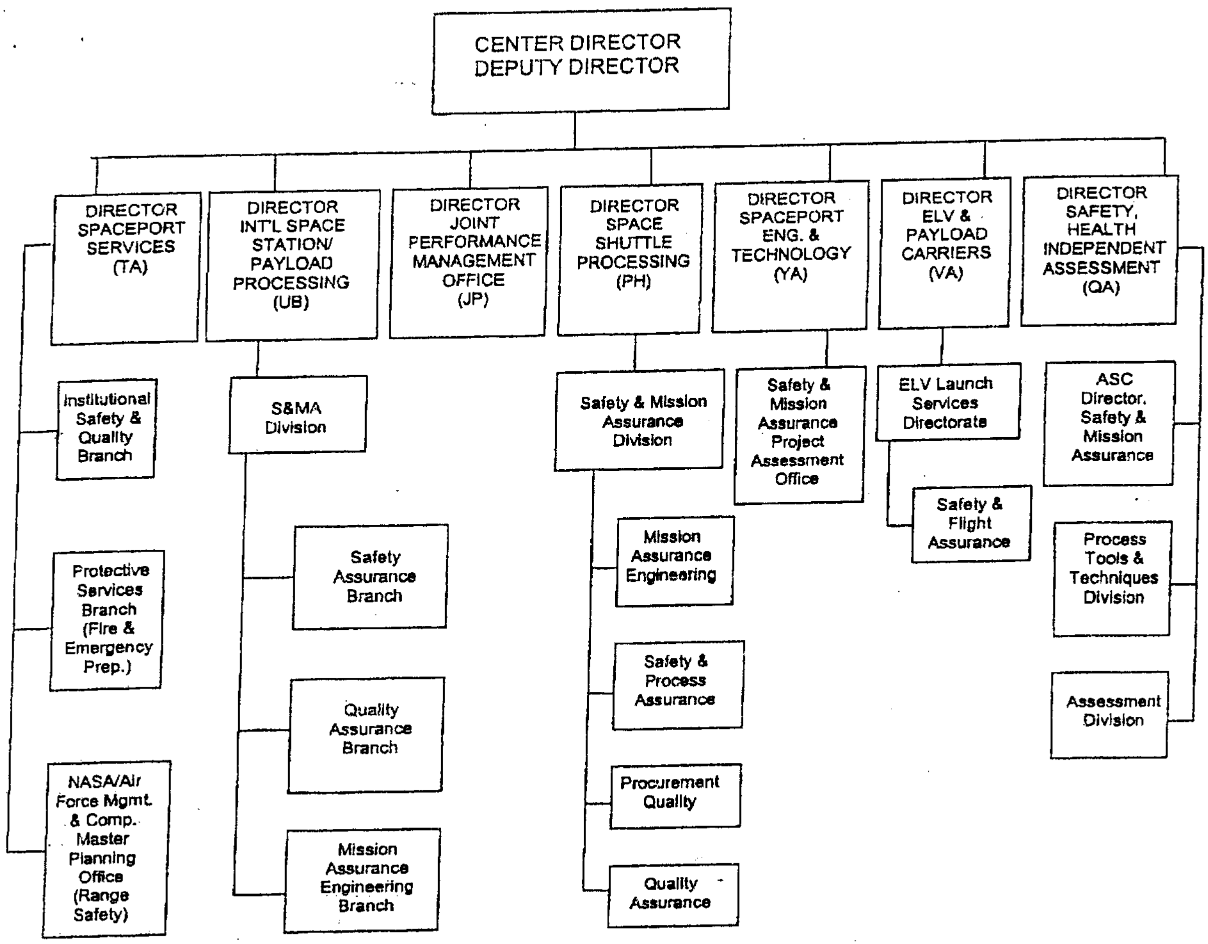
First, world class S&MA implementation requires that everyone take responsibility for safety and quality. While the S&MA organization will be responsible for establishing policy and direction, each supervisor and each person is responsible for safety. First time quality is a goal. NASA line organizations and all elements of the contractor work force must incorporate safety and quality into everything they do. The KSC S&MA organization will be most effective when used as consultants, enablers, teachers, and auditors. This philosophy is being adopted by the center and brings about a real change in the role of the safety and quality professionals.

Second, the agency and the center have adopted Performance Based Contracting. NASA specifies the products they expect and the contractor determines how to deliver this product. The contractor takes on more responsibility and the government role shifts from oversight (in-line) verification to insight (surveillance and auditing). All of the major KSC contracts, including the SFOC contract, are now performance based. Since KSC is planning a major, centerwide reorganization in 2000, these factors may influence the structure of S&MA and its position in this reorganization. These changes will be reflected in the next AOA revision." (36)

Research of S&MA history of this time frame revealed operational changes across the Center. A heavy burden fell on S&MA Director, JoAnn H. Morgan, to reduce the NASA S&MA staff by 35%, and to eliminate her mission support contractors, Analex and Hernandez, another 98 persons. The S&MA ANNUAL OPERATING AGREEMENT (AOA) certainly shows a constant revolution of "management technique" shifts when succeeding

AOA's are studied. The NASA Strategic Management Process aligns all agency planning activity at KSC. Much of the AOA is derived from the KSC Business Objectives and Agreements (BOA). The AOA serves to assure that safety and mission assurance are an integral part of everything done at the Center. The Mission Assurance Program elements are shown in their entirety on pages 36-42 of Chapter 3, "EVOLUTION AND IMPLEMENTATION OF R&QA MANAGEMENT AND DOCUMENTATION."

The following chart depicts the organization of the current of S&MA program linkages at KSC:



Organization Of The Current S&MA Program Linkages at KSC

Chapter 6

HISTORY OF R&QA IN THE INTERNATIONAL SPACE STATION PROGRAM

The launch of STS-88 on December 4, 1998 marked the beginning of the construction phase of the greatest space station to date. The International Space Station (ISS) is putting new worlds within closer reach and more knowledge within our grasp. This step along the way to exploring the universe is a giant undertaking, pushing the envelope in many areas of technology, both on earth-based equipment and on-orbit technology. All of this activity on earth and on the ISS will require creative R&QA implementation to satisfy system engineers and management.

On December 4, 1998, Shuttle Endeavor carried the U.S.- built Unity module in its cargo bay. Upon rendezvous in earth orbit with the U.S-built Unity module, the shuttle robot arm grabbed the Russian-made Zarya control module and linked the two together into the first assembly of the ISS. This action marked a new dawn of the fifteen-year effort of 16 countries to jointly construct the largest international peace-time scientific project in the history of space travel.

During the proposed six-year course of construction, the shuttle will make about 35 flights to the station to add pieces, swap Alpha residents and keep the "lightning-rod outpost" supplied with all on-orbit needs. Yes, the ISS will most assuredly draw the world's attention just as a lightning-rod draws lightning to itself.

Much concentrated work effort is required in the preparation and launch of a Space Shuttle as well as preparation of the payload intended for the ISS. Safety, Reliability, and Quality Assurance play an important role in all the preparation, test and checkout, and in the launch countdown process of each mission to the ISS. Page 96 reflects the current organization structure at KSC that contains SR&QA responsibilities.

The following organization charts show how the ISS/Payloads Processing Directorate is making advances toward getting the job done with respect to the ISS. Mr. Bruce Jansen, UB-F, is shown leading the Safety & Mission Assurance Division where the Safety Assurance, the Quality Assurance Branch, and the Mission Assurance Branch give leadership to the creative R&QA program that is required to complete NASA and contractor SR&QA tasks in the preparation and launch of the many payloads that will be required for completion of the space station over the six-year period:

John F. Kennedy Space Center
ISS / Payload Processing Directorate
Safety & Mission Assurance Division

Safety and Mission Assurance Division (3)

UB-F — Fax (321) 867-5505 — (48)

Jansen, Bruce	Chief	7-5868	SSPF 3214 B
Dollberg, John	TA/GSRP Chair	7-5926	SSPF 3238 Q
Howard, Christian	MSA	7-6505	SSPF 3214 A
Dundas, Chris	Co-op (work)	1-8447	O&C 2052
Snyder, Katie	Co-op (school)		

SUPERVISORY RATIO:
4 Supervisors / 44 Non-Supervisory = 1/11

Safety Assurance Branch (6)

UB-F1 — (321) 867-6551 — Fax 867-9253

Beach, Jeff — Chief — SSPF 3238 E

Hales, Pamela, Lead	7-6554	SSPF 3238 J
Rogers, Jimmie, Lead	7-6573	SSPF 3238 G
Brand, John	7-6126	SSPF 3238 A
Brown, Stephen	7-7697	SSPF 3228 C
Ferruzza, Thomas	7-6553	SSPF 3238 C
Meade, Theodore	7-6569	SSPF 3238 D
Moore, Dennis	7-6572	SSPF 3238 F

Quality Assurance Branch (23)

UB-F2 — (321) 867-3050 — Fax 867-1401

Scaltsas, Richard	Chief	7-3054	O&C 2052
Antonucci, Jerry	QA Integration	7-9491	O&C 2053 B

ISS Element and Test Support

Brunelle, Steve, Lead	7-6587	SSPF 3228 K
Brink, David	7-5937	SSPF 3214W
England, Al	7-5886	SSPF 3220 N
McMahon, Don	7-5881	SSPF 3214 E
Morris, Ron	7-5882	SSPF 3214 F
Rodriguez, Rick	7-6576	SSPF 3214 K

ISS and Shuttle Middeck Support

Arrington, Jon, Lead	7-6578	SSPF 3228 J
Holt, Gary	7-5831	SSPF 3220 H
Rosenberry, John	7-5891	SSPF 3220 G

ISS and Shuttle Payload Process Audits

Antonucci, Jerry, Lead (Act)	7-3050/7-9491	O&C 2053 B
Barry, Steve	1-8443	O&C 2053
Bonde, Mark	1-8444	O&C 2053
Fowler, Dave	7-8527	O&C 2053
Love, Vera	1-8442	O&C 2053
Phillips, Richard	7-2113	O&C 2053
Roeder, Joe	1-8445	O&C 2053

ISS Experiment and Shuttle Middeck Processing

Reed, Jim, Lead	7-6584	SSPF 3020 S
Craig, Gary	7-5888	SSPF 3220 E
Dixon, Dave	7-5885	SSPF 3214 H
Downing, Dave	7-5892	SSPF 3220 L
Eichenlaub, Tom	7-5889	SSPF 3214 G
Hale, Greg	7-5879	SSPF 3220 C

Mission Assurance Engineering Branch (14)

UB-F3 — (321) 867-6574 — Fax 867-9253

Dibler, Dave — Chief — SSPF 3238 P

Quality Engineering

Bodiford, Sandra	7-6577	SSPF 3228 A
Demski, Michael	7-5408	SSPF 3228 B
Hyppolite, Phil	7-6582	SSPF 3238 T
Shoup, Mike	7-5979	SSPF 3238 W
Yencso, Tom	7-6584	SSPF 3238 V

Safety Engineering

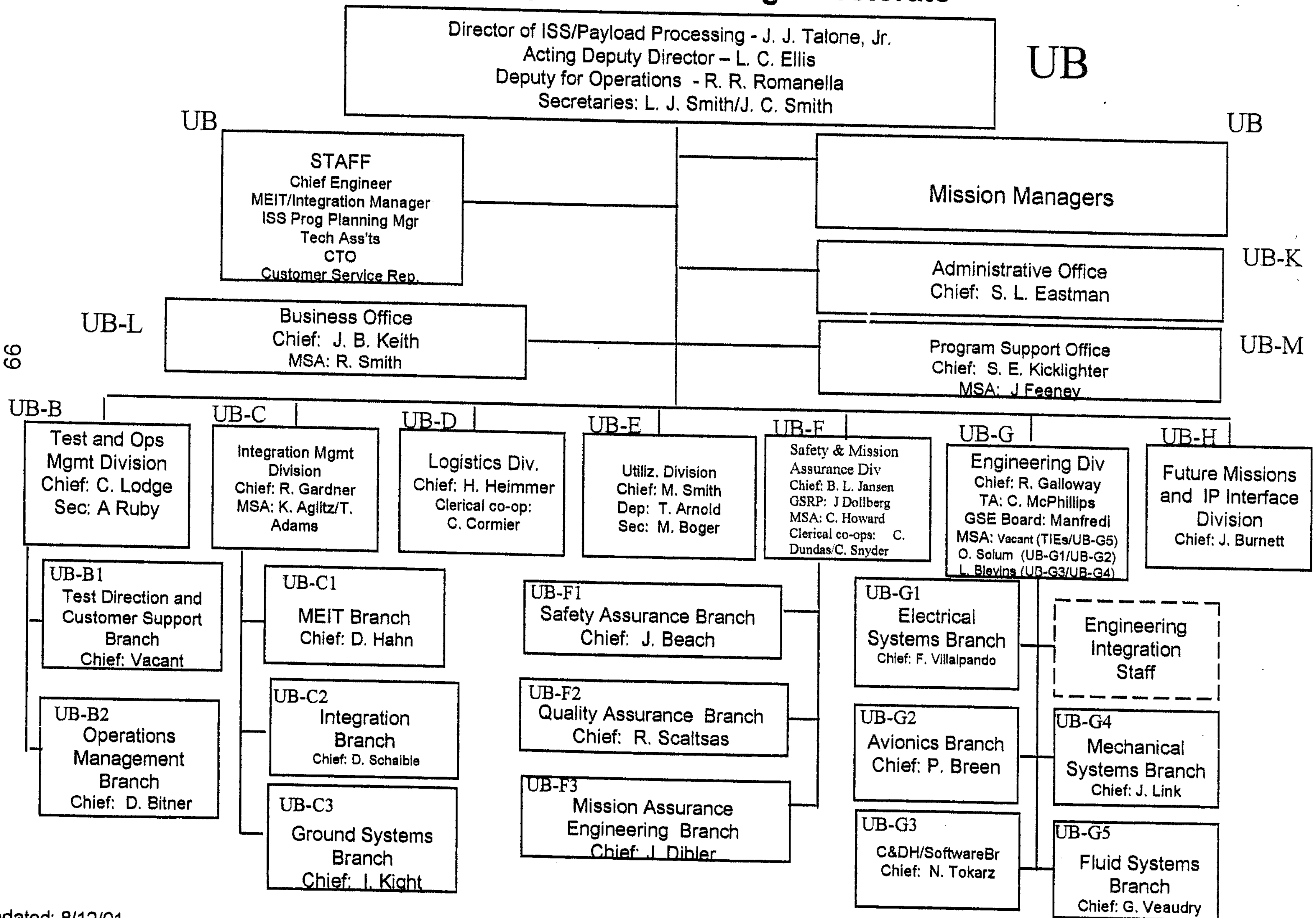
Kirkpatrick, Paul, Lead	7-6568	SSPF 3238 B
Daliwala, Bob	7-6594	SSPF 3238 R
Hardison, Dian	7-6527	SSPF 3228 D
Smith, Mike	7-5283	SSPF 3238 U

Software Assurance

Anderson, Tony	7-6589	SSPF 3220 P
Kanie, Jim	7-5972	SSPF 3220 J
Negron, Abe	7-6591	SSPF 3220 R
Pantano, Lisa	7-5950	SSPF 3220 M

August 20, 2001

ISS/Payload Processing Directorate



Updated: 8/12/01

The McDONNELL DOUGLAS Space Station Freedom Program Plan, MDC Y1159 Rev. Basic, pages 2-2 - 2-9, dated May 1992, shows the careful planning and response to the KSC R&QA requirements invoked in support of the Payload Ground Operations Contract (PGOC) and the Space Station Freedom Program (SSFP), now called Alpha). The following quotes from that document concerning R&QA confirmed an acceptable R&QA program for this particular Contractor:

CHAPTER 2 - QUALITY ASSURANCE

2.1.1 - PLANNING: Quality Assurance activities shall be planned and developed as an integral part of Space Station Freedom design, development, test and evaluation, production, operational activities, and refurbishment/overhaul. Scheduled status reporting will be used to provide visibility and assist in controlling the Quality Assurance effort. Objectives will be to plan and establish the Quality Assurance effort, to define the major Quality Assurance tasks and their place as an integral part of the design and development process, and to assure the effective implementation of Quality Assurance requirements. Quality Assurance program planning shall address all program phases and shall provide a comprehensive management approach to preventing, detecting, documenting, and resolving actual or potential nonconformances.

2.1.2 - ORGANIZATION: The Director, Safety, Reliability, and Quality Assurance (SR&QA), will have responsibility and authority to direct, manage, and evaluate the quality program and make changes to ensure mission success. As shown in Figure 2.1, the Director reports directly to the Vice President, General Manager. This direct access to top management will ensure the effectiveness of the program and will guarantee timely corrective action when problems are identified. Quality Assurance will retain its autonomous and equal relationship to those organizations whose activities and outputs are evaluated. Figure 2-2 details the SR&QA organization.

The Reliability & Quality Assurance organization is shown in Figure 2-3. Quality Assurance engineers will plan the inspection (QA) tasks and coverage in accordance with the Quality Program Requirements Document (QPRD), included as Appendix E of this plan. Additionally, Quality Assurance engineers shall perform design reviews, subcontract reviews, source and site inspections, end-item acceptance, audits, surveys, corrective actions, QA alert coordination, material review, and other related functions. Quality Assurance inspectors will perform the on-line and off-line inspection functions which include product and process evaluations, work document, and nonconformance report controls.

The Sustaining Engineering Project Management organization which reports to the Director, Product Engineering and Definition (PED) is detailed in Figure 2-4. Primary support from the PED Directorate is in the specialized area of criticality assessments and System Assurance Analysis in support of design enhancement.

McDonnell Douglas Space Systems Company
Kennedy Space Center
J.F. McDonnell - Chairman and Chief Executive Officer, MDC
K.A. Francis, President, MDSSC

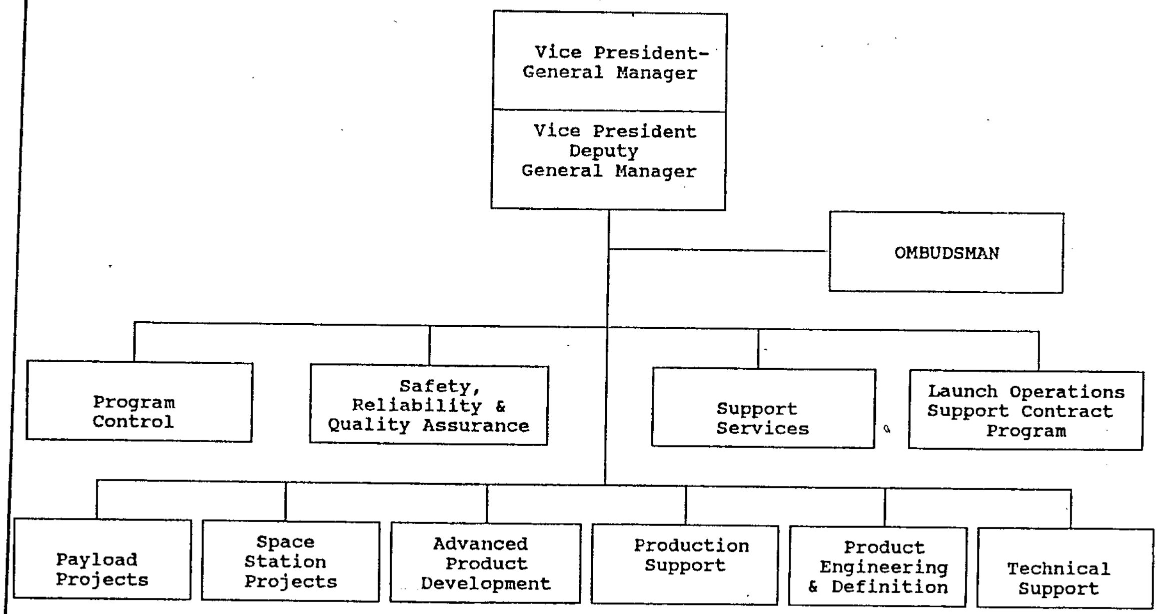


Figure 2-1

McDONNELL DOUGLAS SPACE SYSTEMS COMPANY
KENNEDY SPACE CENTER

SAFETY, RELIABILITY, AND QUALITY ASSURANCE

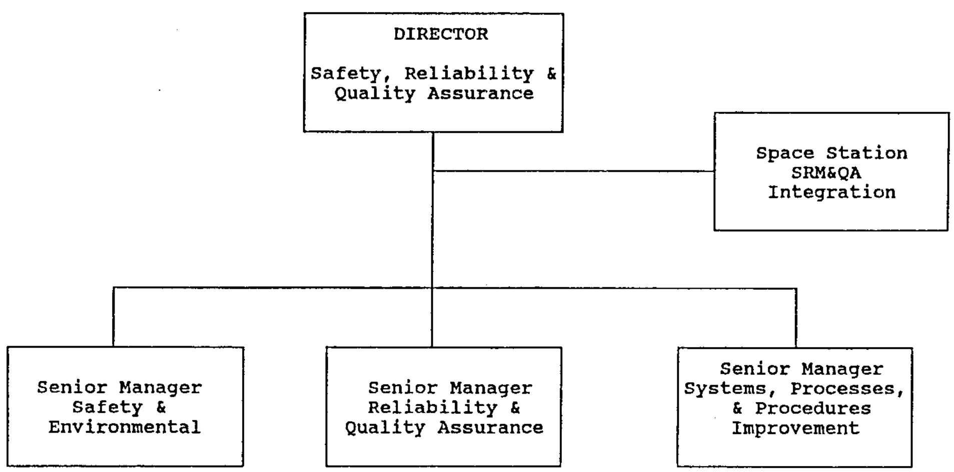


Figure 2-2

McDONNELL DOUGLAS SPACE SYSTEMS COMPANY
KENNEDY SPACE CENTER

RELIABILITY & QUALITY ASSURANCE

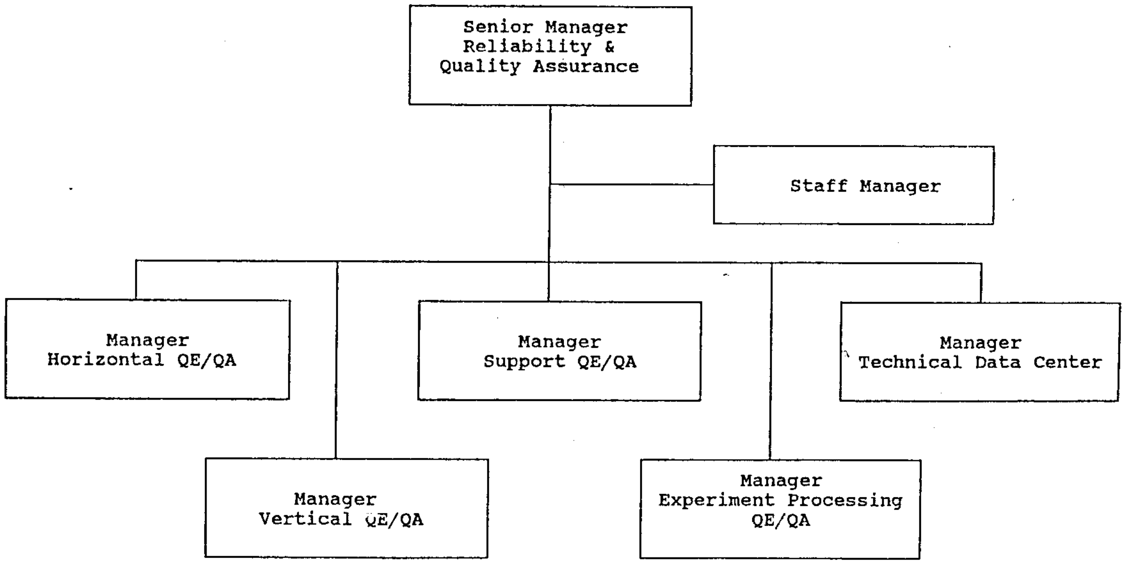


Figure 2-3

McDONNELL DOUGLAS SPACE SYSTEMS COMPANY
KENNEDY SPACE CENTER

PRODUCT ENGINEERING AND DEFINITION

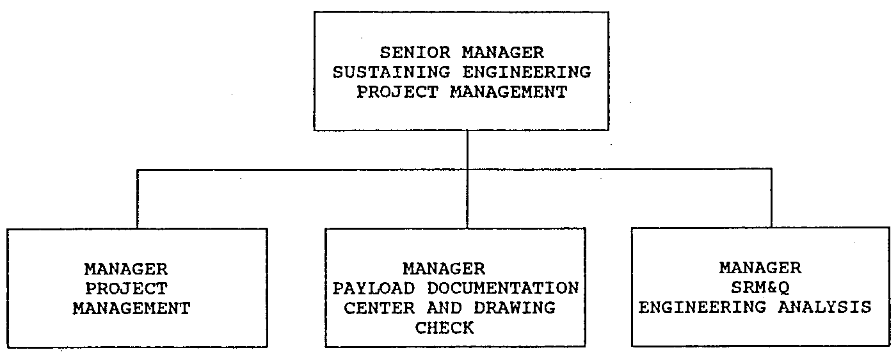


Figure 2-4

2.1.2 Continued: "The Safety, Reliability, Maintainability, and Quality Assurance Integrator is the primary interface at directorate level with customer counterparts, for the Director of Safety, Reliability, and Quality Assurance (SR&QA), and Product Engineering and Definition (PED) on all activities affecting Space Station systems development, activation, and operation. Some of the Integrator's major responsibilities are:

a. Ensures that plans, programs, policies, and procedures are developed to meet program requirements. The Integrator coordinates NASA and MDSSC-KSC tasking requirements with all SRM&QA disciplines and ensures task execution is in accordance with customer requirements from Levels I, II, III, and MDSSC-KSC.

b. Ensures consistent application of Safety and Product Assurance (S&PA) standard practices, policies, procedures, instructions, and other management directives.

c. Ensures the development of integrated goals and formulates and communicates Safety and Product Assurance activities to management and to customers, as required.

d. Participates in NASA and PGOC meetings, committees, and boards. Assures that issues and concerns are fully addressed,

e. Ensures Program Operating Plan (POP) budget and manpower is developed and coordinated with PGOC project management, program control, and NASA SR&QA Project Office with synergism considered for manpower and equipment.

f. Ensures that specific approaches are undertaken in SR&QA and PED, on SCPA activities, to consolidate, synergize, and improve cost effectiveness.

g. Serves as the spokesperson for communication between MDSSC-KSC and NASA SR&QA Directorate on Space Station

h. Functions as the SRM&QA Space Station representative within PGOC. In this capacity, coordinates with all directorates on issues affecting the Space Station Freedom Program. This interface/interaction ensures the SRM&QA issues and concerns are addressed.

i. Determine customer requirements and take initiative to gain customer satisfaction.

2.1.3 QUALITY PROGRAM PLAN

This plan covers MDSSC-KSC Space Station Freedom Program quality assurance functions and is a master planning and control document for these activities. It is our objective and policy to establish, implement, document, and maintain an efficient and effective Quality Assurance program that is fully responsive to NASA contract requirements and McDonnell Douglas Corporation's Total Quality Management (TQM) policy. Principle Quality Assurance functions and major tasks that will be incorporated in SSFP quality assurance planning are:

- Development of clearly defined Quality Assurance tasks, responsibilities, and standard procedures.

- Direct the definition of program quality assurance plans and other deliverable documentation, as required, in accordance with contractual requirements and applicable internal policies and procedures.

- Manage/monitor the preparation of budgets and schedules, monitor performance against approved budget and schedules. Assure sufficient manpower is available using synergistic planning for all projects, payloads, and missions.

- Provide management and supervision of Quality Engineering and Inspection functions (QE/QA),

- Ensure Quality Assurance technical review in design and development to ensure incorporation of design criteria, proper implementation, and documentation.

- Tailor Quality Assurance support for cost-effective consideration of flight, GSE, and facility requirements with maximum use of available resources.

- Assure the transporting, receiving, lifting, handling, storing, and processing of flight elements and associated hardware is performed with utmost concern for established requirements, hardware integrity, and mission success.

- Plan, conduct, and document inspection and test support of material, articles, equipment, and systems.

- Provide Quality Assurance functions of audits, surveys, certifications, recurrence control, proof testing, and source inspection.

- Provide inspection for the early detection and subsequent meaningful corrective action on nonconforming materiel.

- Coordinate with Production Support to provide for segregation, control, and processing of nonconforming raw material, articles, and equipment with historical data and trend analysis.

- Establish cost-effective material review and scrap/excess processing.

- Exercise procurement quality control, including definition of quality requirements and monitoring of supplier performance for compliance with quality requirements.

- Ensure positive control of Contractor-Acquired Property (CAP) and Government-Furnished Property (GFP) in accordance with applicable requirements.

- Assure that any quality related problems are identified, reported to the proper organizations, and corrected.

- Maintain open dialog with NASA counterpart organization on significant problems and accomplishments.

- Ensure conformance to preservation, packaging, handling, storage, and shipping requirements.

- Ensure certification and control of test equipment, facility systems, tools, gages, special processes, and personnel.

- Assure the purchase order, invoice, and certification files are maintained in Receiving Department.

- Develop measurements to establish and approve supplier list in accordance with acceptance/rejection data in the Receiving Inspection and source/field inspection reporting.

- Provide document archives, retrieval, and reference library services for Acceptance Data Packages, closed work authorization documents, nonconformance records, and specifications, standards, drawings, and microfilm services.

- Provide positive acceptance and serviceability identification via stamps, tags, and constraint review procedures, and Acceptance Review (AR) activity.

- Provide general operations and shops surveillance, process monitoring, inspection walk downs, and subcontractor field inspection support. (37)

The Safety And Mission Assurance (S&MA) Annual Operating Agreement (AOA) For FY-2002 and Out-Years, KCA-1702, Rev. A, dated October 15, 2001 states that:

"The International Space Station/Payload Processing Directorate is responsible for the management and performance of all KSC activities supporting the Space Shuttle Payloads/Experiments Programs, International Space Station (ISS) Program, and ISS Payloads/Experiments Programs. The Directorate serves the Center's focal point for Space Station and Payload related requirements, resource allocations, and planning; and has the overall responsibility for satisfying all Center and Program requirements, including S&MA. This Directorate is also responsible for the performance of several ISS Program level tasks including:

oversight of the ISS Program's contractor activities at KSC; tracking and verifying the as-!aunched hardware and software configuration; supporting the ground safety Review Board; managing ihe Ground Safety Review Panel; and surpporting the Ground Support Equipment Board.

The primary objective of the Safety and Mission Assurance (S&MA) Division within the international Space Station/Payload Processing Directorate is to assure that operations at sites under the Directorate's responsibility are conducted in a manner that will achieve mission success. S&MA consists of the Safety, Reliability, Maintainability, Quality, and Software Assurance disciplines that are applied to enhance productivity by reducing the probability of mishaps, failures, maintenance burden, and product flaws. The S&MA Division acts as the S&MA conscience for the Directorate, with a clear voice in NASA and contractor operational and decision-makng processes. The ISS/Payloads Processing Directorate provides technical safety support for ground processing of ELV payloads at KSC through an inter-organizatonal agreement between UB and VA." (38)

The preceding paragraphs documented the McDonnell Douglas' quality assurance responsibilities within the ISS Program. The document, "DDC Y1159," dated May 1992, was their official Quality Assurance Program Plan. Later contract competition awarded the ISS Payload Ground Operations Contract (PGOC), NAS10-11400, to the Boeing Company.

JSC's S&MA functions are achieved throughout several directorates and S&MA organizations. The following chart allows the Center to enhance the S&MA philosophies throughout the line organizations. Support is also provided through KSC S&MA Contractors and other Government Agencies:

SAFETY AND MISSION ASSURANCE ANNUAL OPERATING AGREEMENT	
CENTER: KSC	OFFICE: International Space Station/Payload Processing (UB)
ACTIVITY DESCRIPTION: S&MA Programmatic Requirements Flowdown (e.g., Lifting equipment, explosives, S&MA analyses) Contractor Process Surveillance - GMIPs - Review of GSE/Facility system design, analyses & risk assessments (hazard analyses, hazard reports, SAAs, FMEA/CIL) - Out-of-Family Disp. - Risk Review Board - Award Fee - Audits/Assessments ELV Payload Safety Engineering Safety Engineering for KSC developed Ground Support Equipment /facilities modifications Internal Assessment CoFR Programmatic Support Hands-On QA support for Experiments and Middecks Hazardous Procedure Review/Approval MERB Membership Launch Countdown Support HEDS Assurance Board Support PAR Support GSRP Mishap Investigation Support (Conduct or assist in programmatic investigations) S&MA Metrics/Trending Deviations/Waivers to Program S&MA requirements Compliance with OSHA Requirement 29CFR 1960	
RISK OF DOING NOTHING: Increased probability of personal injury mishaps, failures, maintenance burden, and product flaws. Reduced likelihood of first time quality in the planning, design, development, fabrication, test verification and operations. Increase risk to schedule. Increase in number of Shuttle Payload and ISS elements in-flight anomalies resulting from ground processing.	
METRICS: 1. Percent of procedures reviewed and returned to customer within suspense date. 2. Number of Quality System Assessments completed per KDP 3. Number of processing delays caused by GSRP error 4. ISS and Shuttle in-flight anomalies. ~~5. ISS/Shuttle Payload problem report rate.~~	GOALS: 1. 95% within suspense date. 2. Complete 50 QSA's in FY 2002 3. Zero processing delays caused by GSRP 4. Zero per mission ~~5. Decrease from FY 00~~
TASKS: Support the manifested missions SSP Payloads ELV Payload missions	CUSTOMERS: Space Shuttle, Payloads Carriers, ELV and ISS Programs, Various payload organizations (offline experiments processing delegations), JSC, MSFC, LaRC, GRC, Codes M, Q, and U.
IMPROVEMENTS/INITATIVES: New/improved Quality Surveillance Record Database	

International Space Station/Payload Processing (Activity Descriptions, Metrics, Goals, And Tasks)

The "Introduction" and "Scope" of the Boeing Company Quality System for Contract NAS10-11400 (BP 1001H, dated October 2000), page 1-1, provides the following:

> "This Quality Plan describes the tasks and activities used to implement the Boeing Quality System for Contract NAS10-11400, the Payload Ground Operations Contract (PGOC). The quality system, including quality policy, which applies to all Boeing contracts, is described in the Boeing Quality Management System (BQMS), Company Procedure PRO-4798, the Boeing Quality Management System Model, Company Procedure PRO-570, and the Space Coast Operations Quality Management System Supplement, SCO-PLAN-SMA-001. Information contained in those documents is not duplicated in this plan.
>
> This plan is written using the elements of ANSI/ISO/ASQC Q900A-1994 to allow easy correlation of planned activities to these elements. A cross-reference is also provided in Appendix A to other applicable quality requirements, including SSP 41173 (which applies to NASA Payload Logistics Depot (NPLD) operations in support of the International Space Station (ISS) Program. Appendix A also lists the implementing procedures applicable to each section of this Quality Plan. Paragraphs in the Plan which are only applicable to portions of the contract or which differ from the normal requirements will be specified and specifically marked for that portion of the contract, e.g. , "Experiment Integration Only."
>
> The following precepts:
>
> o Clearly defined tasks and responsibilities in procedures and instructions.
> o Consideration for quality enhancements during early phases of equipment design and development.
> o Improvement of product and service quality through continuous and complete hardware, software and process evaluations and corrective actions.
> o Evaluation of hardware, software, and operations quality through analysis, reviews, and assessments.
> o Integration of quality with all technical and operational departments and with all phases of payload ground operations.
> o Consideration of hardware/task criticality and complexity and system/program maturity during implementation of quality activities.
> o Verification of flight readiness of hardware and software. **(39)**

Further assurance of R&QA coverage is found on page 2-1 of Boeing's BP 1001H, Section 2:

> **SECTION 2**
>
> **REFERENCE DOCUMENTS**
>
> The following documents are used as guidance for establishing specific tasks required for the PGOC quality system:

ANS/ISO/ASQC Q1994,	Quality Systems - Model for Quality Assurance in Design, Development, Production, Installation, and Servicing.
ANSI/ISO/ASQC A8402 -1994	Quality management and quality assurance vocabulary,
SSP 41173	Space Station Quality Assurance Requirements
PRO 4798	Quality Management System
PRO 570	Quality Management System Model
SCO-PLAN-SMA-001	Space Coast Operations Quality Management System Supplement **(40)**

Section 4 of this same document covers Quality Management Responsibility, Quality Policy Implementation, and Organization with a strong emphasis on new Continual Quality Improvement philosophy that empowers people and makes them responsible for their own work, which provides rewards for excellence, and encourages Continual Improvement of procedures and processes. Continual Improvement is a regular topic by KSC management, and this quality philosophy is reinforced thoughout the KSC contractor organizations.

Section 4 of the Boeing Quality Plan contains the following QA Requirements and implementation philosophy:

SECTION 4

QUALITY SYSTEM REQUIREMENTS

4.1 MANAGEMENT RESPONSIBILITY

Boeing executive management takes a leading role in defining implementing, and administering the quality system. In this role, they have adopted and fully embraced The Boeing Company's Quality Policy for application to the PGOC. They have also established the following activities and organizations to carry out the quality system.

4.1.1 Quality Policy Implementation

All employees are provided with training on the ANSI/ISO/ASQC Q0000-1994, standards, the Boeing Quality Policy, and how it applies to their work. New employees are provided with this training as part of their initial New Employee Orientation Training. A 'Continuous Quality Improvement' philosophy has been adopted by executive management that empowers people and makes them responsible for their work, provides rewards for excellence, and encourages continious improvement of procedures and processes. Continuous Improvement is a regular topic of discussion by the executive management. This quality philosophy is reinforced throughout the organization and flowed down to employees at all levels.

4.1.2 Organization

The PGOC Director, Safety and Mission Assurance (S&MA) has been appointed as the management representative responsible for ensuring that the PGOC quality system is established and implemented. The director also has full responsibility and authority to evaluate the quality system and make changes to ensure mission success. The S&MA Director reports directly to the PGOC Program Manager to ensure unimpeded access to top management. S&MA maintains an autonomous and equal relationship to other organizations whose activities and outputs are evaluated. Although the responsibility for providing quality products and services is shared by all personnel and organizations, an S&MA organization has been established with the prime responsibility to plan and carry out specific quality tasks related to contract requirements. This organization and its relationships are depicted in Figure 4. 1-1:

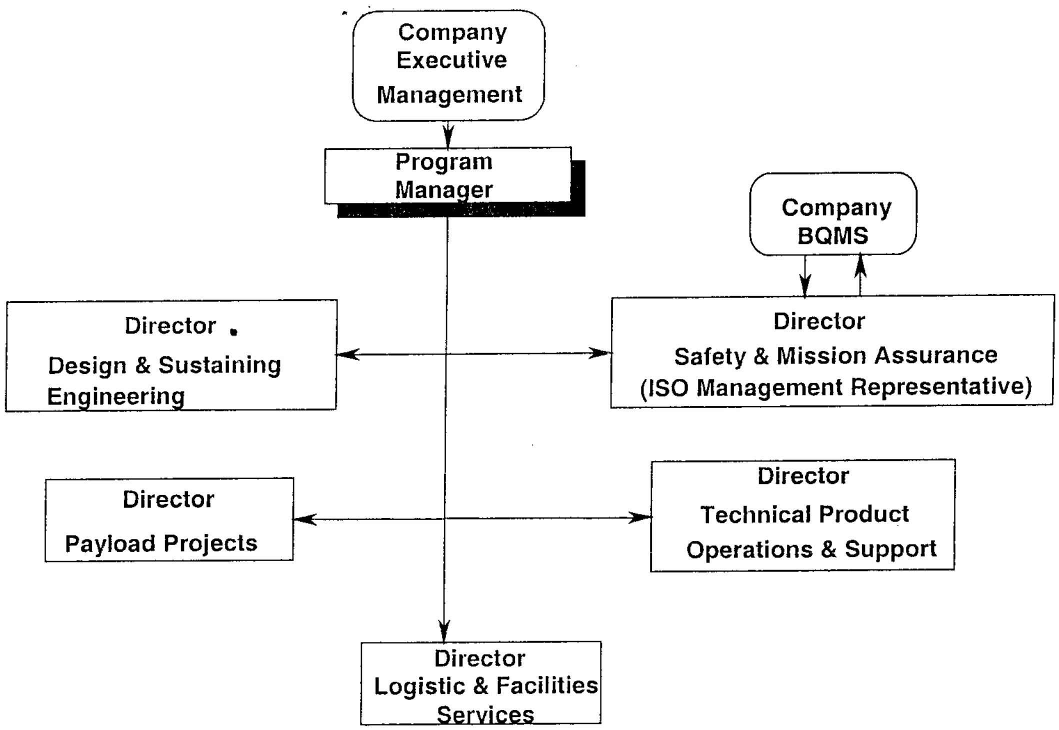


Figure 4.1-1

To ensure that all tasks, responsibilities, and authority for quality are clearly defined and understood, executive management has established a documentation system that includes detailed planning documents, where appropriate, and a series of Standard Practices and Procedures (SPPs), Standard Practices (SP's) and desk procedures for implementation. These procedures and instructions clearly define who is responsible for specific tasks related to the quality system.

Under PGOC, a detailed Program Operating Plan (POP) is submitted to NASA as justification for future budget requirements. POP is estimating rationale for all tasks to be performed, including those tasks related to quality. By reviewing all inputs prior to submission to NASA and allowing each organization the opportunity to provide rationale for their budget, exective management ensures that the resources are available to provide products and services at a quality level expected by the customer. In addition, executive management can redistribute resources within the organization in order to meet quality objectives if the need is determined during periodic quality reiews.

4.1.3 Management Review of The Quality System

Periodic management reviews of the quality system as applied to PGOC are conducted by the Program Manager and senior staff twice per year as a minimum to ensure the continuing suitability and effectiveness in satisfying the requirements of our Quality System policy and objectives. This review provides closure of many such reviews that have taken place at all levels of mangement. Minutes of these management reviews are maintained as quality records. This review process is depicted in Figure 4.1-2:

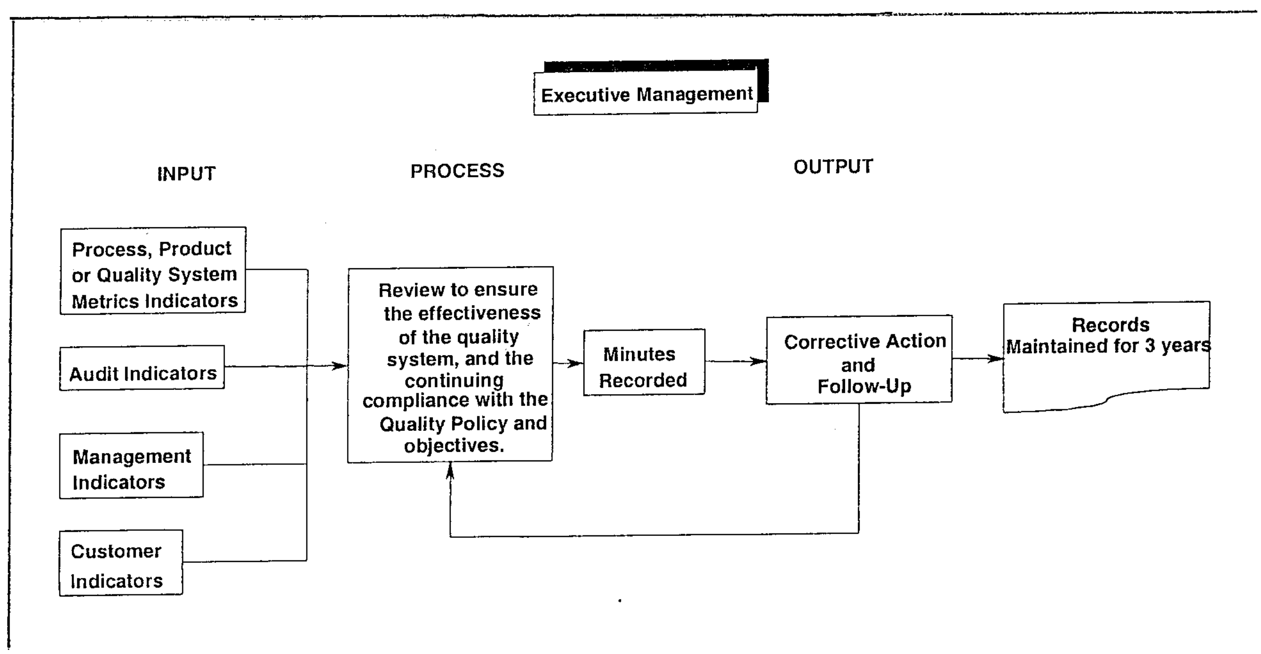


Figure 4.1-2

4.2 QUALITY SYSTEM

4.2.1 GENERAL

The quality system to be used for PGOC is as described in PRO-570 and SCO-PLAN-SMA-001 with additional details provided in subsequent section of this plan. The quality system is implemented using written procedures to define authority and responsibility for specific quality tasks. Written operation instructions are used to define the applicable quality requirements for all phases of payload ground operations and to detail the methods and individual responsibilities for satisfying them.

4.2.2 Quality System Procedures

Planned activities to assure an acceptable level of quality for all products provided under the PGOC are based on hardware/task criticality , and maturity of systems and programs in the implementation of quality activities. Flight hardware processing, other critical tasks, or work on critical systems use procedures that establish stringent controls for carrying out and verifying the work. Work on less critical systems allows use of alternative procedures with less critical systems allows use of alternative procedures with less stringent controls. These procedures and the criteria used to establish criticality of the systems and tasks are clearly defined in NASA and Boeing requirement documents and are implemented by SPs and SPPs.

System procedures are carried out using written work instructions, These work instructions, called Work Authorization Documents (WADs), define the quality requirements to be met, detail the methods for satisfying them, and specific individual responsibilities. Quality activities are integrated with other functions in order to provide a comprehensive program that ensures all quality requirements will be achieved.

PGOC personnel also accomplish contractual requirement for the International Space Station (ISS) as members of Integrated Product Teams (IPTs). IPTs are joint NASA/Boeing teams that operate under charter and technical task agreements approved by the ISS Program Office. For ISS development activities where concepts are being evaluated, the teams may use procedures that are not part of the Boeing Quality Management System. However, once product or processing requirements have been established, the products and sevices are provided using documented procedures that are part of the Boeing Quality Management System.

4.2.3 Quality Planning

The quality planning function for all PGOC payload processing operations, development projects, and new contracts is carried out by Quality Engineering, a

Mission Assurance Department. Quality requirements are evaluated in advance and documented in Quality Planning Requirements Documents (QPRDs) for different aspects of the work accomplished under the PGOC. The QPRDs define the approach and provide inplementing policy and criteria for imposing quality conformance assessment requirements. The QPRDs, along with the associated ground rules for application, are published separately.

Quality planning is implemented as part of documented procedures for review and approval of all work activities and design/development efforts:

o For all work instructions, quality requirements, including inspection activites, are incorporated by task team members as part of the documented WAD development, review, and approval procedure. Quality Engineers and other task team members use QPRD guidelines, knowledge and data from reliability analyses, hardware/software criticality, program maturity, and program requirements such as Operations and Maintenance Requirements Specifications (OMRS) to determine the appropriate quality requirements to be included.

o For equipment design, development and modification, design teams/IPTs determine appropriate design quality provisions by reviewing applicable requirements documents, design specifications and standards. Key quality requirements are documented and verified during the design and development process Quality and Reliability engineers are an integral part of the design review process to assure new equipment designs meet all quality and mission assurance requirements.

o Consideration is given to updating quality control, inspection, and test techniques, including development of new instrumentation, when the nature of the work requires.

o When any measurement requirement involving a capability that exceeds the known state of the art is identified, every effort will be made to ensure that there is sufficient time in the planning to achieve this capability.

The quality planning function also includes provisions for the detection, documentation, analysis, and correction of deficiencies, nonconformances, conditions of marginal quality, and trends that could result in unsatisfactory quality. These aspects of the quality system are discussed in detail in Sections 4.6, 4.10.4.13, 4,14, and 4.20 below.

4.3 CONTRACT REVIEW

4.3.1 General

Contract review requirements prescribed by SCO-PLAN-SMA-001 will be fulfilled by the Business Management Directorate, Contracts function, in accordance with SCO-PRO-BM-001, Estimating Proposal Process.

4.3.2 Review

Under the provisions of SCO-PRO-BM-001, all orders/contracts are reviewed by Contracts at acceptance or prior to submission of a tender. When the order or contract is the result of a response to a formal Request for Proposal(RFP) or Request for Quotation (RFQ), Contracts coordinates with other affected Boeing functions, as required, to adequately assess the organization's capability to satisfy requirements. This review includes provisions to ensure that:

o Any difference between the order/contract and the original RFP/RFQ are satisfactorily resolved prior to the commencement of any order/contracts related activity.
o The order/contract requirements are clearly and adequately defined and documented in writing.
o The Boeing Company and/or its supplier(s) possess the capability to fully meet the order's/contract's requirements.

4.3.3 Amendment to Contract

Contract amendments are made and distributed to the affected organizations in accordance with the provisions outlined in SCO-PRO-BM-001.

4.3.4 Records

Contracts maintains records of the contract reviews as defined in SCO-PRO-BM-001. **(41)**

For the balance of BP 1001H, only the topic heading will be referenced which will give the reader a good indication that a thorough analysis of the NASA Request for Proposal (RFP) was made, and that Boeing's Quality Systems Requirement document BP 1001H was responsive:

4.4 DESIGN CONTROL

4.5 DOCUMENTATION AND DATA CONTROL
4.5.1 General Requirements
4.5.2 Documentation and Data Approval and Issue
4.5.3 Document and Data Changes

4.6 PURCHASING

4.6.1 General
4.6.2 Evaluation and Selection of Procurement Sources Including Subcontractors, Suppliers, and Processors
4.6.3 Quality Records and Purchasing Data

4.17 INTERNAL QUALITY AUDITS

4.18 TRAINING

4.19 SERVICING

4.20 STATISTICAL TECHNIQUES
4.20.1 Identification of Need
4.20.2 Procedures (42)

Having put all the Quality System Requirements into their proper perspective and implementation, NASA can expect a complete response to the PGOC Contractor's document, BP 1001H. In the implementation of each requirement listed, and with proper internal audits and surveys, as well as assigned NASA Quality surveillance, the Shuttle and the International Space Station work-effort should result in reliable launch operations at KSC during the contract period.

A new S&MA management philosophy for FY-2002 and Outyears is defined in the following KCS documents:

Safety and Mission Assurance (S&MA) Annual Operating Agreement (AOA) For FY 2002 and Out-Years (KCA-1702, Rev. A). (Oct. 2001)

Kennedy Space Center Business Management System Manual, KPD-KSC- M-1000, Rev. G.

The Mission Assurance Program elements for the International Space Station project are shown in their entirety on pages 36-42 of Capter 3, of this history.

CHAPTER 7

HISTORY OF RELIABILITY AND QUALITY ASSURANCE WITHIN THE EXPENDABLE LAUNCH VEHICLES AND PAYLOAD CARRIERS DIRECTORATE

The Expendable Launch Vehicles (ELV) program under Kennedy Space Center began officially on October 1, 1965, when Dr. Robert Gray's Vanguard Operations Group transferred to the NASA's Launch Operations Center (LOD) at Cape Canaveral and at the Merritt Island Launch Area (MILA), which was later named the John F. Kennedy Space Center.

Conversation with Dr. Gray on October 18, 2001 revealed that prior to the transfer to Dr. Kurt Debus', team his group relied on quality assurance support from Patrick Air Force Base for inspection and surveillance during launch preparations and launches for several years as needed. After transfer to Dr. Debus' team, NASA Reliability and Quality Assurance required proper NASA coverage for both civil service work and for the support contractors like Pan Am, RCA, CSC, and CSR.

Dr. Gray was the first Director of the ELV organization and then John Neilon, George Page, Charles Gay, and Jim Womack in that order, became Directors.

NASA's Expendable Launch Vehicle (ELV) program which still operates at the Cape Canaveral Air Force Station has a continuous history of successes over the years beginning on December 8, 1956, when Vanguard Test Vehicle Zero(TV-0), was launched. It was actually built as Viking 13 by Martin, a descendent of the Vanguard rocket, Delta, built by Douglas Aircraft Co. The experience and lessons-learned over the years from these rockets was well documented. Information passed back to the launch vehicle developers resulted in world-class launch operations. Many of the advances made were due to the reliability and quality assurance programs which included approved work-authorizing documents and trained personnel.

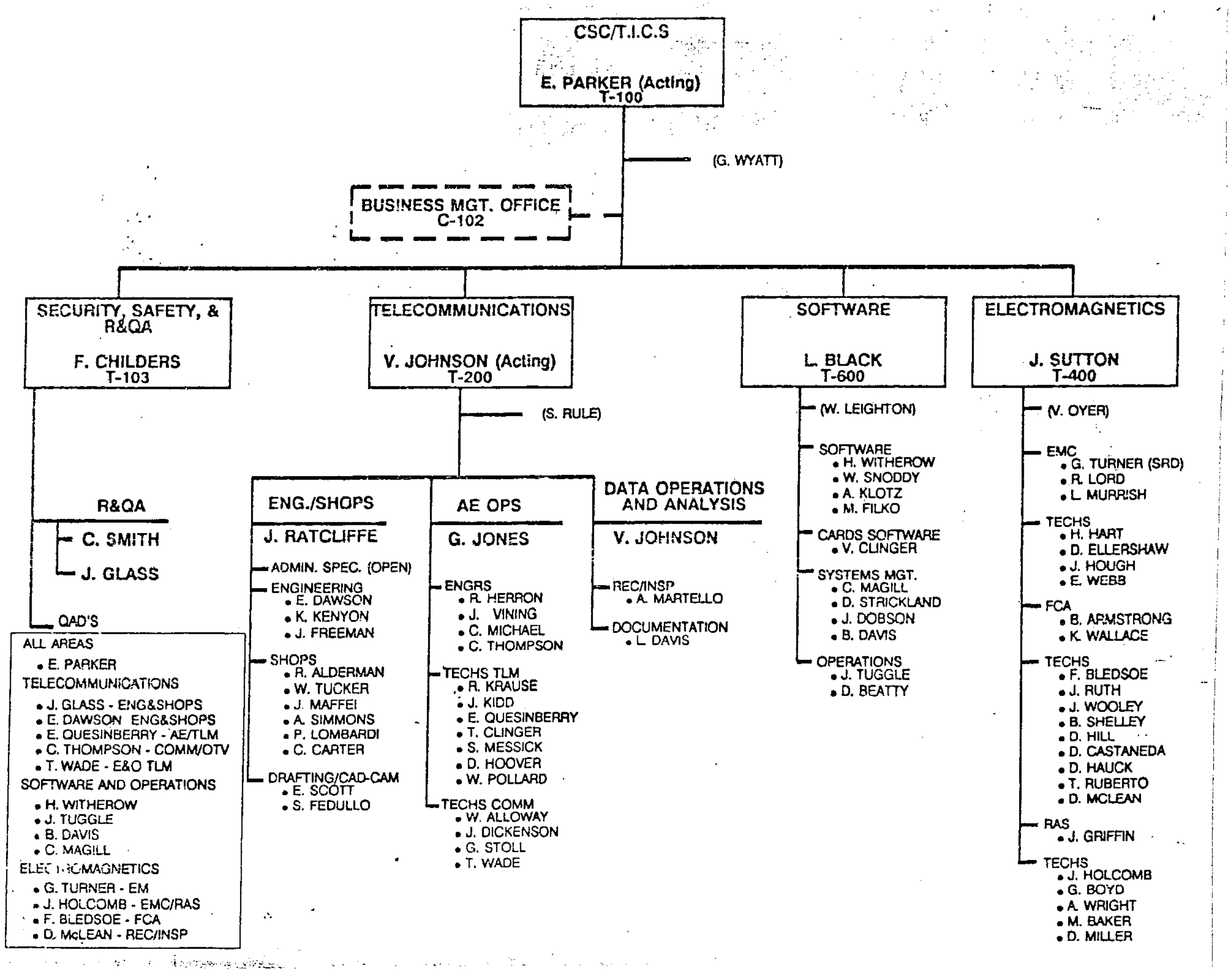
The Kennedy Space Center assigned civil service personnel to ensure contractor compliance for all launch operations at the NASA launch facilities at the Cape. Quality surveillance and contractor evaluation was an important element in assuring successful launch vehicle operations and launchings.

The support contractors over the years were Pan American World Airways (Pan AM), Radio Corporation of America (RCA), Computer Sciences Corporation (CSC), Computer Sciences/Raytheon Corporation (CSR), McDonnell Douglas, and Boeing.

The following organization chart shows the key organizations and personnel during the 1980 time frame for the Telemetry, Instrumentation and Computation Services

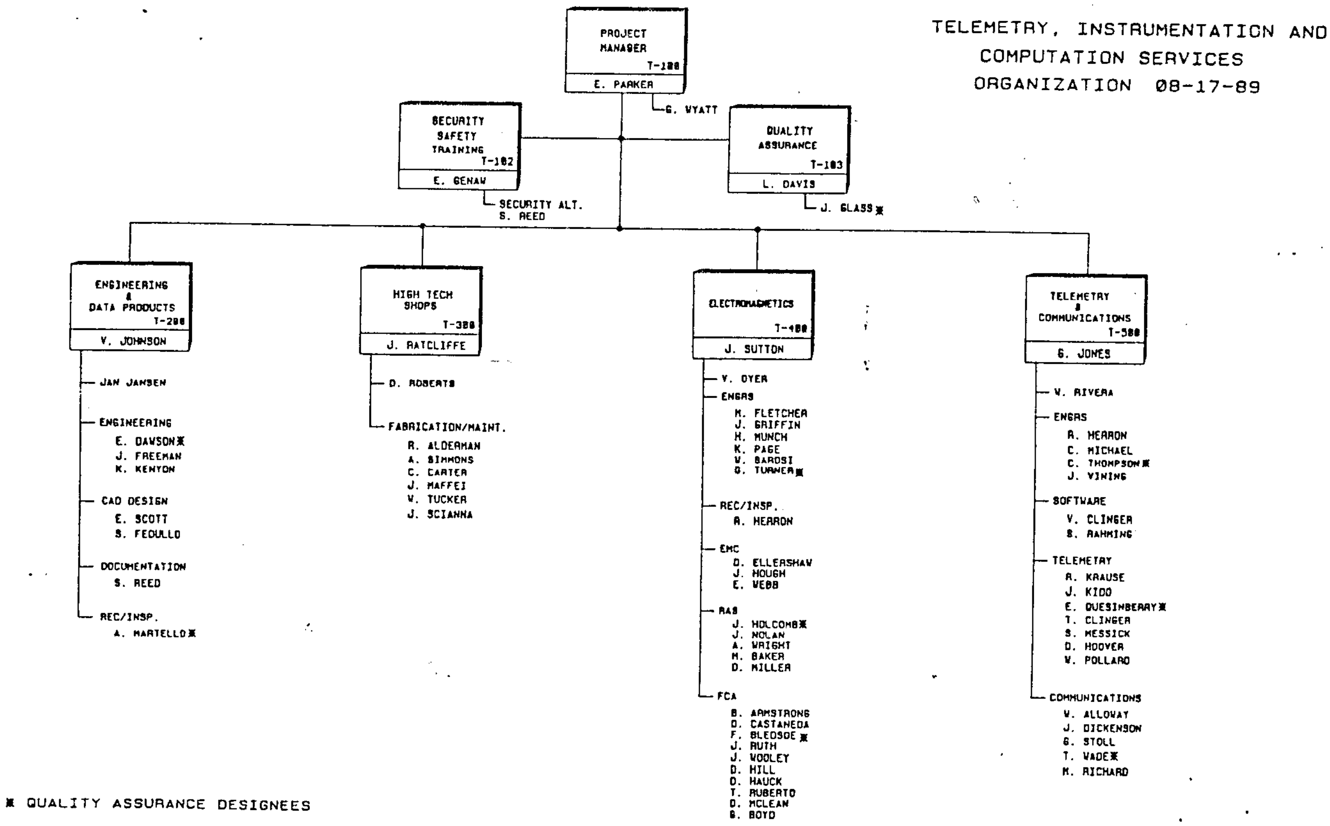
(TICS) contract. Notice that the R&QA organization was headed by this historian for several years until retirement from CSC. (After my retirement from NASA, I worked a total of ten years for CSC in the areas of Safety, Reliability and Quality Assurance).

The chart also shows the assignment of two R&QA Representatives (Smith and Glass) as well as Quality Assurance Designees (QAD's) in the work areas of Telecommunications, Software and Operations, and Electromagnetics. Each QAD was trained and qualified to fulfill the duties of inspection, problem reporting and corrective action system (PRACA), and overall quality support for the TICS contract at Cape Canaveral. A Quality Circle formed of the QAD's met monthly to report advances made, and to review status of corrective action/closure of problems. Management was provided minutes of each meeting for their information and for action required by management.



Telemetry, Instrumentation, and Computation Services Organization, 1983-1986

The next organization chart shows the TICS program under new management changes required by August 17, 1989. The QAD's are flagged in each organization. This method of R&QA coverage was successful for the ELV program over the years CSC held the TICS contract.



Telemetry, Instrumentation and Computation Services, 08-17-89

Succeeding support contractors and NASA were required to have appropriate R&QA responsibilities over the years of ELV operations at Cape Canaveral. The SAFETY AND MISSION ASSURANCE (S&MA) ANNUAL OPERATIONAL AGREEMENT (AOA) FOR FY 2002 AND OUT-YEARS, (KCA-1702, Rev. A, dated October 15, 2001, gives the following guidelines for R&QA:

> The Expendable Launch Vehicle (ELV) Program is a Human Exploration and Development of Space (HEDS) Enterprise, Lead Center Program, responsible for managing and acquiring ELV launch services for NASA and its customers. Fundamental objectives include: provision of safe, reliable, and cost effective launch services for NASA payloads; maximizing the probability of launch success for all NASA missions; and assuring customer launch services are provided within budget. The Payload Carriers Program is a HEDS Enterprise, Lead Center Program responsible for providing payload carriers and support to NASA and its customers. Fundamental objectives include providing expertise, facilities, and associated flight and ground hardware to prepare and integrate a wide variety of spacecraft, and space experiment payloads for flight; providing payload/payload carrier/launch vehicle integration analysis to meet customer and vehicle requirements; and supplying payload carrier upgrades to existing hardware or new carriers to meet future customer demands.
>
> The Safety and Flight Assurance Office (SFAO) of the Expendable Launch Vehicles and Payload Carriers Directorate is the focal point for S&MA activities. SFAO provides consultation and assistance to ELV and Payload Carriers managers in establishing and implementing S&MA requirements. ELV SFAO participates in launch vehicle procurement, design, production, assembly, integration, test, and launch activities. Quality assurance and safety assurance insight and approval activities are performed throughout the launch vehicle life cycle phases. Additionally, SFAO provides S&MA support to the NASA Launch System (NLS) launch vehicle qualification process. They are responsible for concurrence on Level 1 changes serving as a voting member of each Program Requirements Control Board (PRCB). (43)

The Organization chart on page 96 depicts the current Safety and Mission Assurance linkages including the ELV organizations, and the following chart taken from the above AOA presents the overall ELV assignment matrix.

SAFETY AND MISSION ASSURANCE
ANNUAL OPERATING AGREEMENT

CENTER: KSC	OFFICE: Expendable Launch Vehicles and Payload Carriers (VA)

ACTIVITY DESCRIPTION:

S&MA Programmatic Requirements Flowdown
Contractor Process Surveillance, Assessments, Audits, Analysis
- Implement NASA-STD-8709.2 and NPD 8610.23
- CoFR Support

Reviews (Milestone, Launch Vehicle hardware/software).
Payload Safety Engineering
Payload Customer Hazardous Procedure Review/Approval
Hazardous Operations Support
Launch Countdown Support
Failure Investigation/Review
Trending of Quality-Related Process Issues
Contingency Planning/Mishap Investigation Support (Conduct or assist in programmatic investigations)
Deviations/Waivers to Program S&MA requirements
S&MA Metrics/Trending
Procurement Quality
Risk Management
Directorate Institutional/Personnel Safety
Compliance with OSHA Requirement 29CFR 1960

RISK OF DOING NOTHING: Uninformed decision on GO / NO GO for launch; Failure to make our customers aware of anomalies during processing; Increased risk to mission success; and Not identifying operational and safety constraints could compromise operation or risk injury to personnel and damage to facility or flight hardware.

METRICS:	GOALS:
1. Percent of operations conducted without incident or close call.	1. 100 percent
2. Percent of procedures returned by need/due date.	2. 100 percent
3. Percent of procedures worked without incident or close call.	3. 100 percent
4. Compliance with SFAO procedures NASA Std. 8709.2).	4. 100 percent
5. ELV Launch delays caused by Quality problems (Call to Station through Launch).	5. Zero percent
6. ELV Mission success rate.	6. 100 percent
7. ELV in-flight anomaly rate.	7. Zero percent
	Note: Most of these goals are under development and may be updated.

TASKS:	CUSTOMERS:
1. Complete and implement SFAO procedures. 2. Establish a closed-loop tracking process to ensure 100% compliance with NASA STD 8709.2 per mission. 3. Perform six ELV audits in FY 01.	Codes Q, M, S, Y, GSFC, JPL, Payload Owners

IMPROVEMENTS/INITATIVES:	

ELV Assignment Matrix

Expendable Launch Vehicle operations at Cape Canaveral has widely spread responsibility for the NASA expendable launch vehicles which support both government and industry. The following paragraphs taken from the ELV SFAO ROLES AND RESPONSIBILITIES document, dated May 9, 2001, gives insight into ELV operations and responsibilities:

> Organizational Structure: SFAO (VB-D) is the Safety and Mission Assurance (SMA) Office for ELV & Payload Carriers Programs Directorate (VA) and reports directly to the ELV Launch Services Director, Mike Benik (VB). SMS communication relationships are also maintained with the Safety, Health and Independent Assessment (SHIA) Directorate (QA) and NASA Headquarters Code Q.
>
> Expendable Launch Vehicles (ELV) Safety, and Flight Assurance Office (SFAO) consists of government and contractor personnel. Our KSC/CCAFS Office (Eastern Launch Site has Flight Assurance Managers (FAMs), Flight Assurance Engineers (FAEs) and Flight Assurance or Quality Assurance Specialists (QAS)/Quality Assurance Manager and a Safety Officer. Our VAFB Office, (Western Launch Site) has a Quality Assurance Manager, a Safety Manager, a Safety Specialist, and Quality Assurance Specialists. At each of the Chandler (Orbital), Denver (Lockheed Martin), and Huntington Beach (Boeing) Field Offices, we have a Flight Assurance Manager (see SFA0 Organization Chart Figure 1). VAFB, Chandler, Denver and Huntington Beach are considered field or resident sites.

ELV Safety & Flight Assurance Office

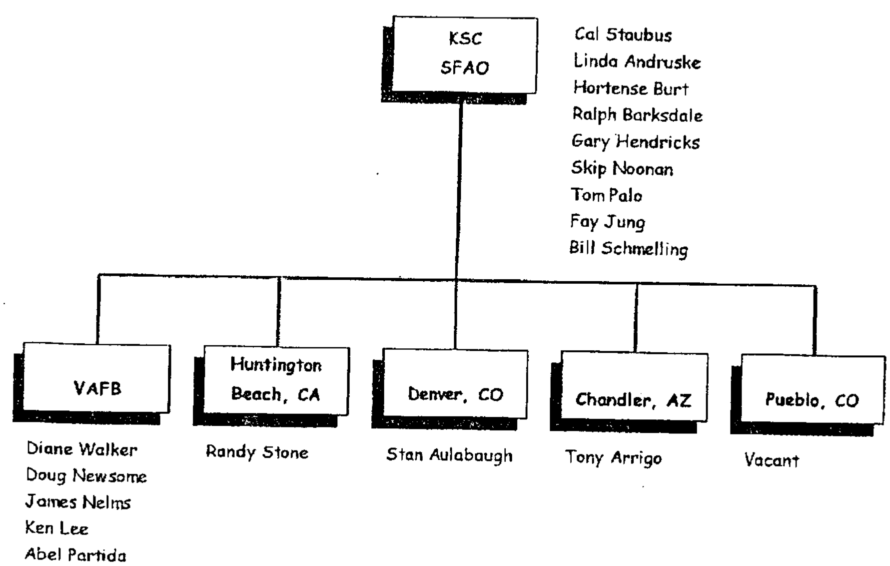


Figure 1

Resources: In addition to the civil service and contractors that make up the core SFAO mentioned above under Organizations Structure, SFAO has additional AMA support. Launch vehicle and mission support is available daily from other ELV Divisions. The International Space Station/payload Processing SMA Division (UB-F) provides ELV ground processing safety support for payload processing through KSC facilities at the Eastern Launch Site through a Service Agreement between their directorates and the ELV Management Agency (DCMA) provides support to the SFAO and the ELV Launch Services Directorate via letters of delegation.

The following paragraphs outline KSC "Roles and Responsibilities:"

KSC Flight Assurance Managers (FAMs) Flight Assurance Engineers (FAEs):

Missions: The FAMs and FAEs have work assigned on a mission basis in order to better comply with NASA Headquarters' ELV SMA requirements. These mission assignments and the respective SFAO points of contact can be found in the ELV Assignment Matrix. The FAM/FAE, for their mission, shall document compliance with K-ELV-10.1 (NASA-STD-8709.2, NPD 8610.23A, NPD-8610,24.A, NASA-STD-8719.8, and EWR 127-1 using SFAO KDPs, desk instructions and checklists. All SFAO resources may be used in obtaining mission insight data. A contingency plan shall be developed for every mission. Primary mission presentations include the CDLVLRR and the Integrated Mission Review (IMAR) with SHIA and code Q. Reviews and meetings are attended for independent SMA assessment and insight into critical issues that could adversely affect mission success. Quality Assurance Reports providing status on open problem reports, corrective action, deviations, waivers and other open paper will be distributed at the FRR and LRR. The mission FAM/FAE will be on console for launch and will provide a "GO" or "NO GO" when polled by the NASA Launch Director.

Vehicles: Work is also assigned to FAMs/FAEs on a vehicle basis to facilitate technical knowledge development and provide an SPAO contact for vehicle issues, Attachment 2 provides an SFAO primary and back-up point of contact for seven groups of vehicles.
Engineering Review Boards (ERBs): FAMs/FAEs will attend ERBs to ensure quality and safety issues are addressed, to ensure ERB processes are followed, and to maintain vehicle insight.
New LSP Vehicle Certification: SFAO roles, responsibilities, requirements and activities for certifying new launch vehicles are covered in K-ELV-10.3.
Insight, Special Studies, Hazard and Quality Assessments, Analyses, Audits, SMA Issues and other work: Studies, analyses, audits, assessments and other work will be assigned on an as needed basis.

Quality Assurance Specialist/Manager:

Missions: Flight Assurance Specialists (FAS), a title that is synonymous with Quality Assurance Specialists (QAS), support the FAMs/FAEs on a mission basis through spot audits and surveillance of LSP activities. The level of surveillance increases throughout the mission phase requiring the greatest amount of surveillance during launch site activities and culminating with the monitoring of closeout processes on launch day. Quality Assurance Reports shall be developed, signed by the FAE/FAM, and distributed by the FRR and LRR. The satisfactory accomplishment of closeout processes by the contractor is reported to the FAM/FAE on consult in support of a "GO" or 'NO GO" for launch. Spot audits and surveillance activities are documented. The Quality Assurance Manager shall coordinate FAS/QAS coverage for all NASA missions.

Formal Audits: The Quality Assurance Manager is responsible for spearheading the NASA formal audits of Launch Service Providers (LSP) as required by NPD 8610.23A (Section 5.c.5). As training takes place, it is expected that all SFAO civil service personnel will perform at least one formal audit annually. As relationships mature, audits of LSP's subcontractors are anticipated to increase. Additionally, audits may be required for new launch vehicle certification per K-ELV-10.3.

Defense Contract Management Agency (DCMA); The Quality Assurance Manager and the Chief of SFAO are the primary points of contact for providing: direction to DCMA and are the Lead Safety and Mission Assurance (SMA) representatives per NPG 8735.2. SFAO field representatives will make recommendations to the KSC Quality Assurance Manager when they deem DCMA support or change of support are needed. DCMA support is performed through a Letter of Delegation (LOD). Daily DCMA operations (within the scope of the LOD) may be addressed by the SFAO site representative. The Quality Assurance Manager will monitor DCMA performance and compliance regarding launch vehicle issues related to NASA ELV missions.

KSC SFAO Support Contractor: Augments the KSC SFAO by performing quality and safety assurance activities and provides mission support and assistance in the development of SFAO presentations, contingency plans, weekly notes, reports, studies, assessments and analyses. The ELVIS Statement of Work (SOW) provides additional information on their responsibilities and insight roles.

VAFB

VAFB Quality Assurance Manager: Is responsible for directing and administering SFAO's quality assurance activities at VAFB. This position ensures that insight activities are performed and documented for flight hardware processing activities at VAFB. The VAFB Quality Assurance Manager is responsible for coordinating SFAO involvement (both civil service and contractor) for Western Range Launches. This position will, assist the FAE/FAM with Western Range launches and develop the Quality Assurance Report for distribution at the FRR and LRR.

VAFB Launch Services Contractor:

Quality Assurance Specialists-Contractor: Are responsible for performing quality assurance activities as stated in the ELVIS SOW and as requested by the VAFB Quality Assurance Manager. This work includes surveillance of spacecraft and launch vehicle flight hardware processing at VAFB.

SFAO FIELD RESIDENT REPRESENTATIVES (Chandler, Denver, Huntington Beach)

The SFAO representatives/FAMs located at the NASA ELV Field Offices are a primary source of SFAO information. They are at the best position to obtain timely flight assurance information from their respective LSP plant and nearby LSP subcontractors. This information is collected, documented and forwarded to the mission and vehicle FAE/FAMs at KSC as well as the SFAO Chief, Engineering Field Office Chief and Vehicle Systems Engineering Lead in support of mission reviews. The SFAO resident office representative FAMs are responsible for performing and providing the following as a minimum:

1. Perform and document weekly surveillance of the LSP
2. Participate in local reviews, meetings, pertinent tests and local site visits. The KSC FAEs/FAMs shall be notified of those events (with sufficient lead time to allow for travel arrangements) to allow the KSC FEA/FAM to attend as needed.
3. Provide comprehensive weekly notes relative to flight assurance issues
4. Perform high-level monthly process assessments
5. Provide trending of LSP LV data:
    a. Nonconformance (NC) issues or problem reports (PR) per mission compared to similar missions
    b. NC or PR per LV critical subsystem
    c. Corrective Action timeliness
    d. Other areas and data as requested
6. Perform special studies, assessments, analyses and reports on special LV issues as requested by the KSC SFAO Office.
7. Review the processing of GIDEP issues impacting LSPs and LV used for NASA missions.
8. Provide a Mission Summary Report to the KSC FAE/FAM for each mission processed by their respective LSP at least three weeks prior to the Center Director's Launch Vehicle Launch Readiness Review (CDLVLRR). This Report shall summarize:

    a. Mission flight assurance activities
    b. The number and type of reviews, meetings and tests that were attended.
    c. Trending charts
    d. Special flight assurance or GIDEP issues
    c. Other data as requested by the KSC FAE/FAM

9. Monitor DCMA activities making recommendations to the KSC Quality Assurance Manager (NASA SMA Lead) and SFAO Chief when direction to DCMA or changes to the LOD are necessary.

SFAO (All)

TRIP REPORTS:

To make the best use of travel funds and to do Government travel effectiveness, a trip report shall be provided for each work trip. Trip reports should be brief and include what major activities were performed and when they were performed. Trip reports may be in bullet form with dates and if necessary hours. You may also want to include important points of contact (names, titles and phone numbers) if they could be beneficial for future use. "Trip reports shall be provided to the SFAO Chief via e-mail within two business days after returning to work from the travel." **(44)**

Training for both NASA and contractor employees is a primary focus during the next few years as this new approach to Mission Assurance (MA) is put into effect. The contract Statement of Work (SOW) provides for such training and for any procedures or plans to assist each organization to keep abreast with requirements and their implementation throughout the mission.

APPENDICES

SECRET
SECURITY INFORMATION
UNCLASSIFIED

MISSILE FIRING LABORATORY

GUIDED MISSILE DEVELOPMENT DIVISION

APPENDIX 1

FIRING TEST REPORT, MISSILE NO. RS-1

15 October 1953

This report contains a summary of the firing activities conducted by Redstone Arsenal personnel in preparation and firing of REDSTONE Missile No. RS-1. The missile was fired at AFMTC, Cape Canaveral, Florida, at 0937 EST, 20 August 1953.

1. FABRICATION

At the time of firing the missile was as specified in the following drawings:

Drawing No.	Title	Manufacturer
J-GM-55000	XSSM-A-14 Redstone Missile Ass'y	
J-GM-55001 A1	Booster Ass'y	RSA
J-GM-55002 A1	Power Unit Ass'y	RSA
J-GM-55003 C	Center Unit Ass'y	RSA
J-GM-55004 J1	Tail Unit Ass'y	RSA
J-GM-55005 A	Top Ass'y	RSA
J-GM-55006 C1	Nose-Unit Ass'y	RSA
J-GM-55007 D	Aft-Unit Ass'y	RSA
J-GM-55008-1	Instrument Group Ass'y	RSA
Rocket Engine	NAA 75-110 (002)	RSA
		NAA

The aft end of the missile was protected from heat by a sandwich type insulator consisting of sheet asbestos between sheet metal. This insulator covered all exposed parts of the missile aft end, including the servomotor housing. Also, a circular flame shield of the dented design with 4 graphite blocks was mounted at the exhaust nozzle.

2. MISSILE EQUIPMENT SPECIFICATIONS

The following equipment was installed in the missile:

Telemetering: Raymound Rosen, 16-channel.

Gyros: Waldorf-Kerns Company
Pitch Gyro - K-165
Yaw-Roll Gyro - K-156

Integrator: #038 (A. Ott Kempten).

Command Receivers: ARN-59 with KY-55 Decoders (two each).

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SECURITY INFORMATION

Radar Beacons: DPN-17 (two).

Pre-flight Cooler: Blower circulated air over dry ice (RSA Design and Fabrication).

Decomposer Screen Pack: Silver-plated screen activated with potassium permanganate.

Expulsion Tube Assembly: Drawing No. GM 63117 (two cylinders with air storage).

Helium High Pressure System.

Rudder Drive (aluminum casting).

3. OBJECTIVES

RS-1 was launched for the purpose of testing:

a. The power plant.

b. The missile structure.

c. Booster control system.

d. Action of missile at low take-off acceleration.

e. Operation of roll control system after cut-off.

f. Automatic separation.

4. MEASURING PROGRAM

Following is a list of all flight measurements used on Missile No. RS-1. For detailed information regarding these measurements, see Measuring Program (REDSTONE Missile Instrumentation System 1).

GROUP	MEASUREMENT	RANGE
Propulsion Unit	Press. HE. in Pressure Bottles	0-3000 psig
	Press. HE Controlled	0-1000 psig
	Press. Top LOX Container	0-50 psid
	Press. Top Alc. Container	0-30 psid
	(Cont'd)	

FIRING TEST REPORT, MISSILE NO. RS-1

GROUP	MEASUREMENT	RANGE
Pro-pulsion Unit	Press. Top Peroxide Container	0-600 psig
	Press. LOX at LOX Pump Inlet	0-50 psid
	Press. LOX at Injector	0-400 psig
	Press. Alc. Pump Inlet	0-50 psid
	Press. Alc. at Injector	0-400 psig
	Press. Steam at Inlet Turbine	0-600 psig
	RPM of Turbine	0-5000 RPM
	Pressure of Exhaust Steam	0-30 psid
	Position Main LOX Valve	0-90°
	Flow Rate LOX	0-25 gal/sec
	Flow Rate Alc.	0-25 gal/sec
	Pressure Combustion Chamber	0-400 psig
Structure Tempera-tures	Skin Temperature Location #1	260°-700°K
	Skin Temperature Location #2	260°-700°K
	Skin Temperature Location #3	260°-700°K
	Skin Temperature Fin #4 - Upper Point	260°-550°K
	Skin Temperature Fin #4 - Lower Point	260°-550°K
	Temperature of Jet Vane Bracket	260°-750°K
	Temperature of Flame Shield Between Fin 1 & 2	260°-1400°K
	Temperature of Flame Shield Between Fin 3 & 4	260°-1400°K
	Temperature of End Frame Between Fin 1 & 2	260°-1000°K
	Temperature of End Frame Between Fin 3 & 4	260°-1000°K
	Temperature of Antenna Cover	260°-1400°K

[illegible]	MEASUREMENT	RANGE
Structure Vibrations	Vibration Instrument Compt. Longt.	± 50g-150 cps
	Vibration Instrument Compt. Pitch	± 5g-150 cps
	Vibration Thrust Frame Longt.	± 250g-1200 cps
	Vibration Thrust Frame Pitch	± 250g-1200 cps
	Vibration Booster Fin #4	± 5g-80 cps
	Vibration Servomotor #1 - Longt.	± 250g-1200 cps
	Vibration Servomotor #1 - Lat.	± 250g-1200 cps
Force	Lateral Force - Air Vane #1	± 1200 kg
Flight Mechanics	Angle of Attack Pitch	± 7°
	Angular Velocity Pitch	± 5°/sec
	Angular Acceleration Pitch	± 20°/sec
	Angle of Attack Yaw	± 7°
	Angular Velocity, Roll	± 5°/sec
	Acceleration Booster Longt.	- 1.1 to +5.4 g
Steering Control	Tilting Program	0-180°
	Gyro Pitch Position - Minus Program	± 10°
	Gyro Yaw Position	± 10°
	Gyro Roll Position	± 10°
	Deflection Jet Vane #1	± 27° to ± 54°
	Deflection Jet Vane #2	± 27° to ± 54°

(Cont'd)

FIRING TEST REPORT, MISSILE NO. RS-1

GROUP	MEASUREMENT	RANGE
Steering Control	Deflection Jet Vane #3	± 27° to ± 54°
	Deflection Jet Vane #4	± 27° to ± 54°
	Voltage Servo Battery	0-42 Volts
	Total Torque Servomotor #1	± 60 mkg
	Torque Air Vane #1	± 60 mkg
Signals	Take off Signal	
	Speed Contacts	
	Cut off Signals	
	Emergency Cut off Signal	
	Separation Signal	
Tele-metering	Zero Measuring Voltage	
	Zero Measuring Voltage	
	(+) Measuring Voltage	
	(+) Measuring Voltage	
	Standard Voltage (+)	
	(-) Measuring Voltage (Tel.)	
	(+) Measuring Voltage	

5. FLIGHT SAFETY PROVISIONS

Flight safety is defined as all safety measures to be taken relative to the missile when in flight. The AFMTC Flight Safety Officer had the sole responsibility over the missile during flight.

The flight safety system was based on a group of ground stations for optical and radar tracking of the missile, as well as real-time presentation of some attitude data via telemeter. For termination of flight and emergency separation, two separate command receivers and transmitter systems were provided. For further details, see

a. Missile Test Request No. 305.
b. Range Safety Plan, REDSTONE, dated 7 August 1953.
c. Flight Safety REDSTONE, dated 14 August 1953.

6. CLIMATIC DATA

The launch time observation for Cape Canaveral, 0937 EST, 20 August 1953:

Cloudiness: 2/10 low clouds bases 3,000 feet and tops estimated at 6,000 feet.

7/10 middle clouds bases 15,000 feet.

5/10 high clouds at 30,000 feet.

Visibility: 10 miles.

Station Pressure: 1013.7 mbs (29.935 in...).

Temperature: 83°F

Relative Humidity: 80%

Dew Point: 76°F

Wind: SSW at 7 knots.

MINUTES OF THE INTRA-CENTER RELIABILITY MEETING
Held October 21, 1964, 1:00 P.M.

The items described in the Agenda (attachment A) were discussed as follows:

1. Purpose

The purpose of KSC GSE Reliability Analyses was stated and no disagreement was voiced by the NASA Division reliability representatives.

2. Schedules and Milestones

a. GE Annual Work Program.

Mr. Pat Mongillo stated the GE contract had been extended by T.O. #18, from October 1, 1964, through January 31, 1965, to cover the projected manpower levels which were submitted in the GE Annual Work Program. This is an interim Headquarters/Center arrangement until the KSC tasks can be structured to comply with General Phillips' directive to have the major emphasis placed on mission oriented tasks in all possible cases. The reliability tasks received less criticism than some other areas; however, they also need more detail in the wording and schedules of outputs expected. Mr. Mongillo stated that if a level of effort task (portion of a task) is necessary, the following must be shown:

(1) The type of work that will be done,
(2) Who will do the work,
(3) How it will be done,
(5) What type of support is required, (i.e., Mechanical Engineers, Electrical Engineers, Typists, and the number of each required),
(6) The reason for requiring a level of effort task,
(7) The length of time that the level of effort will be required.

Mr. Mongillo referenced a set of policy guidelines for NASA Field Center and Headquarters personnel regarding the future utilization of GE-ASD under NASw-410. This policy guideline is attached as Attachment B. Mr. Mongillo further stated that an input would be required by October 30, 1964, in the reliability area.

<u>Action Item:</u>

The Division Reliability Offices will submit a revised GE work statement in accordance with the attached policy statement to the R&QA Office by October 30, 1964. (This requires more detail on mission oriented tasks and justification for any level of effort work. Outputs required of GE are to be shown for two time periods: (1) November 1, 1964, to January 31, 1965, (2) February 1, 1965, to December 31, 1965. The analysis output dates shown on the agenda are presently in the Annual Work Program and are to be reevaluated in the Division submittals.)

b. Detail Schedules.

The R&QA top level GSE analysis effort milestones and schedules were handed out and discussed. An example of a Division type schedule at one level lower than the R&QA schedule is attached for reference purposes, It was emphasized that all inputs listed on the example did not necessarily apply to all Divisions.

Action Item:

Hardware oriented be submitted as a part of the annual work package by October 30, 1964, listing effort milestones, and showing the work period for each effort (the Division schedule attached for reference is to be used as a guide in preparing these schedules.)

3. Status Reporting

a. Management Display: The "GSE Reliability Analyses Management Display" (prepared by GE for the KSC Apollo R&QA Office) was discussed and is intended to be used by the R&QA Office as a means of keeping program status. This will be forwarded to the Division Reliability Offices in the future for comment.

b. Periodic Status Reports from NASA Organizations to the R&QA Office.

Mr. Joyner suggested the idea of having the Divisions. submit progress or status reports on a regular basis to the R&QA Office to serve as the means of enabling the R&QA Office to keep abreast of program status and problems encountered. Mr, Hall suggested that a status report be submitted every 30 days giving a summary of program status and problems encountered. Mr. Hooker stated that he did not want to prepare a separate report each month to be submitted,to the R&QA Office. Mr. Joyner stated that GE is required to submit a monthly progress report of task progress and that, in lieu of a report prepared by Mr. Hooker, the requirements could be met for forwarding the GE monthly progress report.

Action Item:

A monthly progress Report covering the previous month's effort on the GSE Reliability Analysis will be submitted by each KSC. Division reliability coordinator to the R&QA Office during the first week of each month. The first report should be submitted for the month of October.

4 Organizational Structure

A hand-out of the GE & KSC contact.points on GSE reliability analysis was passed out and discussed.

ATTENDEES

INTRA-CENTER RELIABILITY MEETING
October 21, 1964, 1:00 P.M.

Name	Organization	Phone Number
Pat Mongillo	PR3	UL 3-2552
Frank Childers	ET3	UL 3-9363
Tom Tromley	GE (ET3)	UL 3-6611
Mike Verbosh	GE (ML5)	783-2471 Ext. 365
Ray Pinder	GE (PA6)	UL 3-6711
Wayne Priddy	VT4	UL 3-6104
Charlie Hall	FR	UL 3-5678
Dave Schweizer	GE (VT4)	UL 3-6481
Red Fraunfelder	GE (VT4)	UL 3-6481
Pres Neal	GE (FR)	783-2471 Ext. 370
John Hooker	DR	536-7011 (Huntsville)
Bob McKinney	FR	UL 3-6311
Roy Lee	GE (FR)	783-2471 Ext. 370
Mal Heffelman	GE (FR)	783-2471 Ext. 369
Fred Christ	PA6	UL 3-6104
Jim Bennett	GE (PA6)	783-2471 Ext. 308
Ernie Zanetti	GE (PA6)	783-2471 Ext. 319
Jim Joyner	PA6	UL 3-6104

Intra-Center Reliability Meeting
October 21, 1964 - 1: p.m.

4

A G E N D A

A. Objective

The objective of this meeting is to provide for the coordination and clarification of the overall KSC reliability analysis program.

B. Agenda

1. Purpose of KSC Reliability Analysis

   The purpose of the KSC reliability analysis program is to identify and eliminate system "weak links" through the use of FEA's Criticality Analyses, Contingency Plans, etc.

2. Schedules and Milestones

   a. GE Annual Work Program (Handout & Discussion)

      Overall schedules for initial analysis outputs established in the Annual Work Program are:

LC 37B	LC 34	LC 39
Dec. 1, 1964	Mar. 1, 1965	Mar. 1, 1965

   b. Detail schedule of GSE Reliability Analyses is required.

3. Status Reporting

   a. Management Display

   b. A periodic status report from NASA organizations of progress (outputs, such as FEA's completed), is most desirable.

4. Organizational Structure

   Handout of Working Organization Diagram

Attachment A

POLICY GUIDELINES FOR NASA FIELD AND HEADQUARTERS PERSONNEL REGARDING THE FUTURE UTILIZATION OF GE/ASD UNDER NASw-410

The following information has been developed in order to provide the several NASA organizations with general guidance regarding the future use of GE/ASD under NASw-410 in the Apollo Program.

Wherever possible, mission tasks should be utilized.

(a) During the course of the Apollo Program, the several NASA Centers and the Apollo Program Office here at Headquarters will utilize the services and talents of the General Electric Company in carrying out certain specified portions of the program on both a level of effort and mission oriented basis.

(b) Level of effort tasks are those tasks in which the contractor is required to provide a given amount of manpower (man-hours, man-months, etc.) for the performance of specific tasks. Mission oriented tasks are those tasks in which the Contractor is required to provide an end-product as the result of his efforts on a specific task. This end-product may be either the provision of a piece of equipment or the submission of a report or other software item. In level of effort tasks, the Contractor's performance is measured contractually on the basis of the amount of man-months supplied to a given task. In a mission oriented task, the Contractor's performance is measured by the acceptance by the Government of the software, reports, or equipment that has been developed under the contract. The measurement of acceptability in this latter case is usually by comparing the product delivered to detailed, performance or objective specifications or criteria that were provided by the Government as a part of the contract at the beginning of the task.

(c) It is the intent of NASA that all organizations within NASA doing business with General Electric under NASw-410 make a concerted effort to have General Electric perform future effort under mission oriented tasks.

(d) The above statement should not be construed to mean that all tasks placed in the GE Contract must be on a mission basis. Where items of work cannot be identified and defined sufficiently to permit the measurement of Contractor's performance except in terms of the amount of technical effort contemplated, it is more appropriate under these circumstances to use a level of effort contractual arrangement rather than to attempt to force fit the work into a mission task.

(e) When level of effort tasks are used, the NASA user organization is responsible for taking the necessary steps to make certain that the work is administered properly and is not done on a bodyshop basis: Therefore,

1. The GE/ASD technical personnel should not receive direct day-to-day technical supervision from NASA supervisors. The placement of work orders or tasks should be accomplished through a contractor supervisor.

Attachment B

2. The GE/ASD personnel should not be integrated with NASA personnel in NASA facilities. Provisions should be made to clearly identify and segregate from other Government employees those contractor personnel whose duties require performance in total or in part at a Government installation.

3. Provision should be made for specific task assignments to be given where the nature of the services to be performed does not permit other than a broad definition at the time that the contract is executed. Task assignments, where required, should be in writing, under the technical direction clause of the contract.

Technical Areas where GE/ASD may be used.

Since General Electric began work on the Apollo Program in February 1962, several redirections or changes in emphasis have occurred with regard to GE/ASD's role in the program. Their role, however, can be summarized to include the following:

1. Engineering support for the NASA Headquarters, Apollo Program Office and the three Field Centers in the general areas of integration, checkout, and reliability assessment.

2. Checkout Hardware for the NASA Field Centers at Cape Kennedy (MILA) and at other locations.

3. Support Operations and Technical Systems for the Saturn V Test Stands and other test area facilities at MTF.

Both NASA and GE/ASD have had some past difficulty in attempting to define what effort should be included within the areas of integration, checkout, or reliability support. In many cases, the placement of a particular task into the work statement resulted in considerable confusion as to whether the task was more closely associated with integration, checkout, or reliability.

Beginning with the next contract year, on October 1, 1964, it is proposed to revise the work statement for NASw-410 so that the work statement matrix will be broken down by the four NASA user organizations and under each of these organizations by:

1. Checkout Equipment and Related Engineering Design, and

2. Other Engineering Support.

It is felt that this organization will more clearly reflect the role of General Electric in the Apollo Program and eliminate some of the apparent confusion that existed earlier regarding the distinction between the technical areas of Integration, Checkout, and Reliability. (Note: The MTF portion of the contract will not be affected by the revision of Section I work statement. It will still remain as it currently is written under 5.0 of the work statement.)

The new matrix will also emphasize GE/ASD's major role in the Apollo Program-- in the areas of design and fabrication or procurement of Checkout Equipment for MILA and other NASA specified locations. In addition to this responsibility, GE/ASD can also be used in an engineering support role by the several NASA user organizations. NASA's use of GE/ASD in this area should be on work that is :

1. Well defined,

2. Of significant value to the Apollo Program, and

3. Within the intent of the NASw-410 Procurement Plan and Sole Source Justification.

One point should be clear. The revision to the work statement structure should not be considered by the NASA user organizations as a license to have GE/ASD do all types of work that need to be accomplished by NASA. (The original procurement plan and sole source justification prepared for NASw-410 are still the controlling factors with regard to the use of GE/ASD under NASw-410.) Therefore, GE/ASD should not be requested to do any work under the new work statement matrix for NASw-410 that could not be included under the old work statement matrix organization of Integration, Checkout, and Reliability.

Utilization of GE/ASD Manpower and Facilities.

NASA user organizations should plan their work so that the manpower and facility capability that GE/ASD has developed under Contract NASw-410 is utilized by NASA and utilized in an effective manner. Any buildup or increase of GE/ASD manpower or facilities at Daytona Beach, or at the three NASA Centers (KSC, MSC, and MSFC) over and above those presently available should be accomplished only on a planned and predetermined basis. It is, therefore, important that when a NASA user organization plans to place work with GE/ASD under NASw-410 that they assess the impact of this work on the total capabilities of GE/ASD. When it is determined that new work will require an increase in personnel or facilities, other alternatives, such as the utilization of the capability of other GE departments through interdepartmental purchase orders, the use of available industrial capacity elsewhere in the country through subcontracting, or the provision of Government furnished equipment or material to GE/ASD, should be explored prior to authorizing the additional work to GE/ASD. A well-defined "make or buy" program should be developed on each procurement which details equipment, services or materials to be obtained by subcontract, GFE or through GE/ASD interdepartmental purchase orders. This will assure that GE/ASD's growth is on a planned and controlled basis.

A review of long range planning information from all of the NASA user organizations will be made periodically in order to take into consideration the overall impact of NASA requirements on GE/ASD manpower and facility capabilities. It is expected that these reviews will be able to focus on the proposed trend of GE/ASD business with NASA under NASw-410 and relate these trends to the desirability of increasing GE/ASD departmental facilities and personnel.

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

TO : Mr. Frank M. Childers, IN-QAL

DATE: MAY 16 1968

FROM : Contracting Officer, NAS10-4967

SUBJECT: Appointment as Reliability and Quality Surveillance Alternate Technical Representative

Reference: (a) KSC Organization Management Notice 23 - Government/ Contractor Relationships for Nonpersonal Services
(b) KMI 5330.3, "Assignment of Quality Surveillance Technical Representatives"

1. Pursuant to the Contracting Officer authority delegated to me by the KSC Procurement Officer's memorandum, dated July 27, 1967, you are hereby appointed the Reliability and Quality Surveillance Alternate Technical Representative of the Contract Technical Manager for the Communication & Instrumentation Support Services Contract (Instrumentation) and delegated the following responsibilities and authorities in connection with the administration of Contract NAS10-4967 with Federal Electric Corporation.

a. Identify specific Reliability and Quality work requirements to be performed by the Contractor, levying those requirements which fall within the contract scope of work, and establishing priorities as necessary for timely accomplishment. Directions or instructions to the Contractor which are not within contractor scope, schedule, or cost will be issued through channels by the Contracting Officer.

b. Monitor the Contractor's effective and efficient use of manpower and Government-owned equipment. Review Contractor workload and recommend any changes required in Contractor resources to fulfill valid requirements.

c. Monitor Contractor overtime utilization within the limitations of the contract, and recommend approval to the Contracting Officer of Contractor overtime requests which exceed 20 hours per person per week.

d. Monitor the Contractor to assure that the Contractor provides the directorate reliable test support of high quality and provide an independent estimate of Contractor capability in this activity.

e. Approve the Contractor Reliability Management Plan and the Quality Assurance Inspection Plan including revisions. Request revisions to either plan as required.

f. Provide the Contractor with such technical data and information as may be required and necessary to enable contract performance. Provide technical guidance to the Contractor in the interpretation of and compliance with the Reliability and Quality provisions of the contract. Conduct necessary liaison and coordination with all KSC organizations and the Contractor in all aspects of reliability and quality assurance.

g. Approve or issue such technical requirements as may be required and authorized by the contract. This includes the issuing of Reliability and Quality procedures which will assign responsibilities by organizational element for given programs.

h. Monitor the Contractor to ensure the Contractor provides a R&QA system to take timely and effective action to correct any unsatisfactory reliability or quality conditions. Provide direction to increase effectivity.

i. Monitor the Contractor to ensure the Contractor establishes and maintains a R&QA program which satisfies the contractual requirements. Monitor the implementation of the R&QA system to provide direction to increase effectivity and to assure compliance with the agreed-to program plans and individual test assignments.

2. As the delegated Reliability and Quality Surveillance Alternate Technical Representative, your R&QA effort will include the following:

a. Monitor the Contractor's receiving inspection activities in sufficient depth to determine effectiveness of controls and procedures.

b. Establish controls and perform or witness inspections during process, fabrication, assembly, testing, or operations to determine and ensure conformance to drawings, specifications, and other contractual documents, including design intent. Provide a continuous evaluation of the Contractor's performance and physical verification of quality status.

c. Monitor the Contractor's change control system and ensure that only authorized changes are made and that they are documented. Advise the Contract Technical Manager as necessary in technical review of Contractor engineering change proposals and requests for contractual deviations or waivers.

d. Monitor the Contractor's calibration procedures, methods, techniques, and schedules to ensure that procedures and accuracies are maintained in accordance with contract provisions.

e. Monitor the Contractor's stores control system to ensure that it provides effective protection of materials and articles subject to deterioration, loss of identification, or damage.

f. Monitor the Contractor's failure reporting and corrective action system to ensure prompt and effective reporting and follow-up action.

g. Ensure that equipment logs are maintained in all Contractor-operated areas and reviewed for proper content and format.

h. Monitor the Contractor's Integrity Control System to assure compliance with approved procedures.

i. Monitor and spot-check Contractor-initiated support services requests and requests for supplies to assure that Contractor quality assurance official has evidenced review of the requests for appropriate reliability and quality requirements.

j. Coordinate and arrange for Government Source Inspection as necessary.

k. Visit subcontractor's plants as necessary to ensure compliance with Reliability and Quality provisions of the contract. Make recommendations for corrective actions to the prime contractor.

l. Review and approve quality and reliability program and inspection documentation developed by the Contractor to determine and ensure that articles and processes conform to the contract.

m. Monitor reliability and qualification testing performed by the Contractor to assure that approved procedures were followed and that statistical sample was adequate.

n. Monitor the Contractor's quality inspection stamping activity and ensure that only authorized personnel are issued quality status stamps.

o. Monitor the Contractor's "Identification for Traceability Program" to assure compliance with established directive.

p. Monitor the Contractor's training and certification program to assure that required training has been completed and that specified proficiency is being demonstrated.

q. Ensure that the Contractor surveys his own in-house quality assurance and reliability functions.

r. Serve as a member of the Material Review Board when such board is authorized. Evaluate and disapprove when necessary, members of the board.

s. Identify problem areas, resolve those that are within the scope of your authority, and refer the remainder to the Contract Technical Manager, with recommended solutions.

t. Assure through surveillance of the Government/Contractor operations that compliance with the spirit and intent of NPC 401 and related KSC policies is in evidence.

u. Identify new and potential hazards and making appropriate reports.

v. Execute and fulfill such other duties of the Contract Technical Manager as may be delegated.

3. The authorities listed above shall not be construed to include the power to execute or agree to any modifications of the contract nor attempt to resolve any dispute concerning a question of fact or law arising under the contract.

4. The foregoing delegation of authority will be exercised in accordance with applicable provisions of law, NASA Regulations and Procedures, and other governing authority, and is restricted to that period of time during the absence of the regularly assigned Technical Representative.

5. This appointment shall become effective upon your acceptance and shall remain in full force and effect until completion of Contract NAS10-4967 or until amended or revoked by me, my successor, or higher authority. Further, the appointment will automatically terminate upon your reassignment or separation from duty as an employee of the Kennedy Space Center.

John F. Kolasa
Contracting Officer

CONCUR:

Contract Technical Manager

cc:
Contract Technical Manager
Personnel Office, AD-PER (for employee's personnel file)
Federal Electric Corporation
Management Support Office, TS-MSO
Procedures and Inquiries Section, AD-PRO-15
Plans and Policy Office, QA-PLN
First Stage Section, AD-PRO-21
Contract File

ACCEPTANCE

I hereby accept the appointment as Reliability and Quality Assurance Alternate Technical Representative for Contract NAS10-4967.

Frank M Childers
Alternate Technical Representative

May 17, 1968
Date

APPENDIX 4

T. Childers

POSITION RECORD

1. POSITION NUMBER	4992
2. NAME OF NASA ACTIVITY	John F. Kennedy Space Center
3. LOCATION	Kennedy Space Center, Florida
4. CLASSIFICATION	GN-713-020

	POSITION TITLE	NASA CLASS CODE		
A. NASA TITLE	AST, Meas. & Instr. Systems	NCC: 730-01-S		
		SERVICE	SERIES	GRADE
B. CSC TITLE		GS-	1301.1-	13

5. ORGANIZATION *(Give titles of all organizational breakdowns in descending order)*
KSC/Director for Information Systems
Quality Surveillance, PF

6. OFFICIAL POSITION CERTIFICATION	7. OFFICIAL CLASSIFICATION CERTIFICATION
This is a complete and accurate description of position	TYPED NAME OF CLASSIFICATION SPECIALIST
TYPED NAME OF SUPERVISOR: Daniel D. Collins	T. M. Strong
DATE: 19 Oct 66 — SIGNATURE: D. D. Collins	DATE: 1-31-67 — SIGNATURE: T. M. Strong

8. DUTIES PERFORMED

Incumbent executes a quality surveillance program for the Director, Information Systems that increases and maintains a high level of reliability in the instrumentation systems throughout the organization.

1. Maintains close liaison with Center Reliability and Quality Assurance (R&QA) management in carrying out assigned functions, outlining methods of implementation for R&QA policies, directives, and requirements applicable to Information Systems, delineating areas of responsibility and lines of communication in accomplishing tasks.

2. Assures that KSC Apollo Program Directive No. 2 to report, document, and correct all unsatisfactory conditions in launch related equipment is implemented, serving as the focal point for numbering, editing, distributing and status reporting. Assures implementation and review of station equipment logs for establishing operating time, down time, system mean-time-to-repair and deviations from established standards and configurations. Monitors implementation of NHB 5300.2 "Apollo Metrology Requirements Manual" as applicable and participates in the Instrument Calibration Recall System, GP-229 as directed.

9. ANNUAL POSITION REVIEW *(Audit)* & CERTIFICATION

SUPERVISOR	INITIALS				
	DATE				
CLASSIFICATION OFFICER	INITIALS				
	DATE				

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3. Insures that appropriate quality assurance and reliability program requirements are invoked in launch essential equipment procurements, tailoring requirements to each procurement commensurate with hardware criticality and fulfillment of program needs. Participates in pre-award surveys, bidder conferences, and contract negotiations. Insures that hardware contractors comply with reliability and quality assurance requirements by monitoring their performance through implementation of Program Reviews and assessments at the vendor's facility. Performs analysis of resultant reliability and quality assurance data such as Failure Mode Effect and Criticality Analysis, Design Specifications, Failure Reports, Equipment Logs, and parts or materials information to establish a background confidence base on the supplied hardware.

4. Maintains technical cognizance over all quality assurance and reliability reporting activities of the operation and maintenance service contractors, keeping records of certified personnel with periodic review of their work as applicable, reviewing work in terms of personal or delegated assessment of finished projects or work in progress, results shown in reports, degree of observed ability of individual personnel and proper utilization of skills of such personnel. Keeps informed of latest innovations in soldering, welding, conformal coating, and advancements in quality standards, human engineering, and maintainability.

5. Maintains liaison with personnel of other operating divisions of the Center working in related areas through attendance at meetings and evaluation of technical literature originating within the Center, requiring a thorough knowledge of the overall ground instrumentation systems in determining requirements and limitations imposed on the Directorate.

6. Reviews and evaluates technical literature originating within the NASA Centers, other government activities, and industry pertaining to space vehicle and ground support systems to determine whether concepts, principles, and theories developed by others may be incorporated in the accomplishment of assigned functions. Investigates by correspondence or personal contact, developmental phases which warrant further research. Maintains information on state-of-art and advances in instrumentation components and systems, which enhance overall system reliability.

7. Participates in a critical parts and materials program for all instrumentation systems collecting pertinent data on preferred parts, components, hi-reliability parts, latest materials and processes. The program requires a knowledge of automatic data storage and retreival. Participates in the inter-NASA ALERT Program for dissemination of information on known condemned parts and materials.

8. Keeps informed of prototype tracking, timing, instrument calibration, facility and environmental measurement, data transmission, calibration standards, telemetry, data display, electromagnetic compatibility and other RF system details through participation in design reviews and study of resultant documentation. Reviews for adequacy the maintenance, calibration, and operational procedures, and monitors qualification testing of systems, submitting resultant recommendations to cognizant design personnel for possible implementation. Provides task direction in performing part or component failure analysis and in preparing reliability test plan specifications in participation with the design engineers, where system testing is required to evaluate the level of reliability, assuring that efficient methods are used, that test criteria are valid, and sample sizes are suitable for the requirements of the instrumentation systems involved.

9. Participates in system tests and launch tests to provide system reliability and quality assurance visibility to the Directorate and performs assessment of specified Apollo Tests at LC-34, 37, and 39, submitting consolidated reports summarizing results of tests covered.

10. Technically directs other personnel of the Quality Surveillance Office on a project basis when required and provides specific task direction to contractor personnel in carrying out assigned functions.

Performs other duties as assigned.

Works under general supervision of the organizational segment Chief who issues assignments in the form of a requirement. Incumbent plans approach and method of accomplishing assignments. Finished work is reviewed only for adequacy. Guidance is available in unprecedented situations.

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA GEN. REG. NO. 27

5010-107

UNITED STATES GOVERNMENT

Memorandum

APPENDIX 5

TO : Mr. R. Wojtasinski, ES3

DATE: March 17, 1965

FROM : Instrumentation Reliability & Quality Coordination Office, ET3

SUBJECT: Reliability Program Requirements for Hydrogen Fire Detection System

1. The specification for the above system was reviewed by this office. Based on information provided by you (that this system is basically made up of "off-the-shelf" subsystems) the following reliability requirements are recommended for the "RFP" as per paragraph 1.2 (a) of NPC 250-1, Reliability Program Provisions for Space System Contractors:

a. A predicted or operational reliability statement (i.e., mean-time between failures and associated confidence level) for the system and seperately identifiable equipments within the systems will be supplied. Testing, prediction, and application history which will support the reliability statement must be included. In the case of "off-the-shelf" items, performance experience in operational environments would be satisfactory background for the reliability prediction. This information should be submitted with the technical proposal.

b. Paragraph 3.2, NPC 250-1 - Design Specifications - The contractor's reliability organization shall review and concur with all contractor generated design specifications. All specifications shall adequately cover performance and environmental profile requirements, safety margins, derating factors, and apportioned reliability goals for the system. These specifications shall be updated as necessary, and shall be subject to NASA review.

c. Paragraph 3.6, NPC 250-1 - Design Review Program - The contractor shall establish and conduct a formal program of planned, scheduled, and documented design reviews at the system level. The design reviews shall be participated in by appropriate personnel from KSC (or a designated representative) and the contractors reliability and design organizations. (All reliability information accumulated on the equipment to be reviewed shall be presented in the design review meeting.) Design review reports shall be signed by such personnel to indicate concurrence with the completeness of the review and actions taken.

d. Paragraph 3. 4, NPC 250-1 - Failure Mode, Effect, and Criticality Analysis - A failure mode and effects analysis (FMEA) shall be performed on the newly designed portions of the equipment. A list of FMEA's that were performed during the design of "off-the-shelf" equipment should be provided. Additionally, as an integral part of conceptual design process, the contractor shall develop projected analysis at the system level to determine possible mode of failure and their effects on the overall system performance.

e. Paragraph 3. 5, NPC 250-1 - Maintainability and Elimination of Human Induced Failure - The reliability program shall apply the principles of human engineering and maintainability in all operations during design, development, manufacture, test, and operation of the system or subsystem. The design shall incorporate human engineering features that minimize the possibility of degrading reliability through human error during operation or maintenance.

f. Paragraph 3. 7, NPC 250-1 - Failure Reporting - Failure reporting shall be initiated during all phases of the contractor's effort for newly designed equipment in accordance with paragraph 3. 7 of NPC 250-1. Failure reporting shall be initiated for "off-the-shelf" items during integration and system tests in the same manner. A copy of each failure report must be submitted for KSC information.

g. Paragraph 3. 9. 3, NPC 250-1- Parts Selection - A description of the selection effort used to purchase parts and materials for each piece of newly designed equipment, and a description of the parts and materials application reviews conducted to assure proper application in each piece of equipment will be furnished.

h. Paragraph 3. 10, NPC 250-1 - Equipment Logs - Equipment logs shall be initiated and maintained on all equipment performing a seperately identifiable function in accordance with paragraph 3. 10 of NPC 250-1, and turned over to KSC upon contract completion.

i. Paragraph 4. 3 - Testing - Formal reliability demonstration tests will be included to the extent required by the contract. Reliability demonstration tests will be conducted at the highest practicable level of assembly.

j. The contractor shall include as a seperate section of his proposal, a detailed description of his proposed reliability program that will be employed to meet the reliability requirements of this procurement. The section provided shall satisfy the requirements of NPC 250-1, Appendix B.

k. The contractor shall, upon contract completion, submit the appropriate documentation as listed in NPC 250-1, Appendix F, such as to satisfy (b), (d), (f), (g), and (h).

l. Existing contractor methods for failure reporting, equipment logs, design reviews, etc. should be applied to KSC requirements whenever possible.

m. It is the intention of NASA to have the contractor provide a reliable system. If sufficient performance data for "off-the-shelf" equipment is available to ensure NASA of the reliability of this equipment, submittal of this data to NASA will satisfy our needs. The only additional data required is equipment performance when used within the system. For this reason the requirements above concentrate on new design efforts and overall systems test.

2. The Quality Assurance Office, MQ3, will submit the appropriate quality assurance requirements directly to you.

F. M. Childers

F. M. Childers

cc:
T. Michalek, ES3
D. D. Collins, ET
R. L. Body, PA6
T. Walls, MQ3

TECHNICAL PAPER
PREPARED BY FRANK M. CHILDERS, IN-QAL 1975

Incorporation of Reliability Requirements into KSC Procurements

PURPOSE

The purpose of this paper is to set forth some basic NASA and KSC requirements and some basic criteria for ensuring that appropriate reliability requirements are incorporated into KSC procurements of Space Shuttle Ground Support Equipment (GSE).

POLICY

KMI 5310.12A/QA "Incorporation of Reliability and Quality Assurance Requirements in KSC Procurements" states that it is KSC policy to incorporate appropriate reliability requirements in procurements. It further states that requirements will be tailored to the criticality, complexity, state-of-the-art, cost, schedules, and the amount of research and development required.

REFERENCE

NHB 5100.2, NASA Procurement Regulations
NHB 5300.4(1D), Safety, Reliability, Maintainability and Quality Provisions for the Space Shuttle Program
KMI 5310.12A/QA, Incorporation of Reliability and Quality Assurance Requirements in KSC Procurements

GENERAL

NHB 5100.2, "NASA Procurement Regulations" requires that reliability requirements be considered early in procurement and design stages of critical systems/hardware. Further, NHB 5300.4(1D), "Safety, Reliability, Maintainability, and Quality Provisions for the Space Shuttle Program" requires definition of major reliability tasks and their place as an integral part of the design and development process.

NHB 5300.4(1D) RELIABILITY PROVISIONS AND SUGGESTED IMPLEMENTATION METHODS

1. NHB 5300.4(1D), Par. 1D300.1

Reliability Management

The contractor shall maintain a reliability activity planned and developed in conjunction with other contractor elements. Reliability functions shall be an integral part of the design and development process and shall include the evaluation of hardware reliability through analysis, review, and assessment. Timely status reporting will be utilized to facilitate control of the reliability effort. Major elements of Reliability Management are:

The contractor shall be responsible for the planning, management, and effective execution of the reliability effort. The accomplishment of some reliability tasks may not be the responsibility of the reliability activity, but Reliability shall monitor and ensure that the tasks are effectively accomplished.

Implementation

This paragraph of responsibility is clear enough for contract language and will not require tailoring for contractor implementation.

2. NHB 5300.4(1D), Par. 1D300.2

Reliability Plan

a. The contractor shall prepare and maintain a Reliability Plan which describes how the reliability requirements will be implemented and controlled. The plan shall be prepared in accordance with the applicable information requirements list/information requirement description (IRL/IRD).

b. Reliability effort at each remote test site shall be governed by a self-contained separate section of the overall Reliability Plan or by a separate plan written for each site. The contractor shall identify those sites which require a separate plan.

Implementation

Supplement or substitute the above NHB 5300.4(1D) requirements with the following:

The contractor shall provide, as a portion of his proposed reliability program plan, a detailed listing of specific tasks, man-loading per task, procedures to implement and control these tasks, and organizational unit the authority and responsibility for executing each task. The contractor shall include, as a separate section of his technical proposal, a Preliminary Reliability Plan that will be employed to meet the reliability requirements of the procurement.

The prospective contractors selected for contract negotiations shall submit to KSC, thirty days prior to contract negotiations, an Intermediate Reliability Program Plan. The Plan shall, as a minimum, cover all reliability requirements specified in the statement of work/request for proposal (RFP).

Within sixty days after contract award, a final Reliability Program Plan shall be submitted to KSC for approval. Approval or disapproval shall be stated by KSC within three weeks after receipt. In the event of disapproval, the contractor shall submit a revised Reliability Program Plan, incorporating KSC comments, within thirty days after notification of disapproval.

The allowance of sixty days for preparation of this formal plan shall not relieve the contractor of the responsibility for immediate initation of those reliability program actions agreed upon at contract negotiations which require initiation at the conceptual design stage for full effectiveness.

3. NHB 5300.4(1D), Par. 1D300.3

Reliability Audits

The contractor shall conduct audits of his internal reliability activity and those activities of his suppliers. These reviews shall evaluate progress and effectiveness and shall determine the need for adjustments or changes in the reliability activities. Audits shall be conducted at appropriate intervals (at least annually).

Implementation

This NHB 5300. 4(1D) provision may be supplemented with a requirement for NASA participation in contractor audits as required. Appropriate intervals should be agreed to upon approval of final Reliability Program Plan.

4. NHB 5300. 4(1D), Par. 1D300. 4

Reliability Progress Reporting

The contractor shall report on the progress of the reliability effort through periodic management meetings.

Implementation

This NHB 5300. 4(1D) provision may be implemented with the following:

"The contractor shall submit a reliability activity and status report monthly for the purpose of managment review and program control. The periodic progress report shall include information on the technical progress of the reliability program including significant accomplishments, milestones reached, problem areas, and possible program slippages. These reports may be combined with other program documentation provided all pertinent information is contained or summarized in one report, a section of a report, and supporting information is adequately cross-referenced and readily available."

5. NHB 5300. 4(1D), Par. 1D300. 5

Supplier Control

a. The contractor shall ensure that the reliability of system elements obtained from subcontractors and suppliers meets the reliability requirements of the overall system. This applies to items obtained from any supplier whether in the first or any subsequent tier or whether the item is obtained by an intra-company order from any element of the contractor's parent organization. The contractor shall provide requirements, guidance, and controls to ensure the adequacy of subcontractor reliability implementation. The level of reliability requirements imposed on subcontractors and suppliers shall be appropriately tailored and identified to be consistent with those imposed on the prime contractor and shall include the state of hardware development and complexity, supplier experience, hardware unit cost, and hardware use.

b. Where off-the-shelf hardware is anticipated, the contractor in the selection process shall examine historical data such as other contractor and program requirements and experience as well as reliability history, including failure mode and effect analysis (FMEA), maintainability, problem reporting and corrective action, electrical, electronic, and electromechanical (EEE) parts control, materials specifications and applications, test data (certification and acceptance testing), and design data. The results of this examination shall be documented and additional reliability controls, as appropriate, shall be applied.

Implementation

This provision of NHB 5300. 4(1D) may be supplemented or replaced with the following:

For basically off-the-shelf equipment (that is little or no research and development involved), the bidder shall state those provisions of NHB 5300. 4(1D) or provisions of the RFP that were satisfied during the design of each separately identifiable piece of equipment. The reliability should include, but not be limited to the following:

a. Predicted or operational reliability statement (i. e., meantime between failure and associated confidence level) for the system and separately identifiable equipment within the system to be supplied. Testing and application history which will support the reliability statement must be included.

b. List of failure mode and effect analyses conducted on each piece of equipment and resultant effect on the design of that equipment.

c. A description of the selection effort used to purchase parts and materials for each piece of equipment supplied. A description of the parts and materials application reviews conducted to assure proper application in each piece of equipment.

d. Derating factors used and safety margins present in design.

e. Application, location, and types of redundancy.

f. The type of design reviews held and at what states of design development. Effects of these reviews on equipment design.

6. NHB 5300.4(1D), Par. 1D300.6

Reliability of Government-Furnished Equipment (GFE).

The contractor shall be responsible for the identification of the reliability data needed on GFE. Where examination of these data or testing by contractor indicates inconsistency of the reliability of GFE with the reliability requirements of the overall system, NASA shall be formally and promptly notified for appropriate action.

Implementation

This NHB 5300.4(1D) provision is adequate for incorporation in KSC procurements without revision or supplementation.

7. NHB 5300.4(1D), Par. 1D301.1

Reliability Engineering

The contractor shall accomplish the following reliability engineering tasks on all flight equipment and launch essential ground support equipment (GSE), spares, and GFE, as specified:

Reliability Design Criteria

Reliability design criteria for each subsystem shall be developed and utilized in the design and shall serve as a checklist to ensure compliance of the design to the criteria. The contractor's reliability effort shall include a system for the review and concurrence of design specifications and changes. The review shall ensure that the set of specifications covers all items of hardware and contains applicable reliability design criteria and requirements.

Implementation

This NHB 5300.4(1D) provision may be supplemented with the following:

The contractor's reliability organization shall review and concur with all contractor-generated design specifications. All specifications shall adequately cover performance and environmental profile requirements, safety margins, derating factors and apportioned reliability goals for the equipment. These specifications shall be updated as necessary, and shall be subject to NASA review.

8. NHB 5300.4(1D), Par. 1D301.2

Trade Studies

The reliability effort shall include participation in design trades and shall utilize reliability numerical estimates, as appropriate.

Implementation

This NHB 5300.4(1D) provision is adequate for incorporation into KSC procurements, as desired.

9. NHB 5300.4(1D), par. 1D301.3

Failure Mode and Effect Analysis (FMEA) and Critical Items List (CIL)

The contractor shall establish a system for the preparations, maintenance and control of FMEA's and CIL's.

The contractor shall prepare design FMEA's at the lowest level of system definition required to support the potential uses (e.g., testing, failure reporting and corrective action, preparation of mandatory inspection points, etc.). FMEA's will be performed to the "black box" level and within the "black box" to pursue all critical functions. The identification of failure modes to the piece part level will be accomplished when these failure modes are criticality 1 or 2. The FMEA shall include an integration of all flight hardware, including GFE, and launch essential GSE. The contractor effort shall include the necessary interface with the GFE contractors to ensure compatibility so that the integration can be accomplished effectively.

Based on results of the FMEA's, a CIL shall be prepared consisting of a Single Failure Point Summary (SFPS) and a summary of redundant elements in life or mission essential components where:

a. The redundant elements are not capable of checkout during the normal mission turnaround sequence; or

b. Loss of a redundant element is not readily detectable by the flight or ground crew; or

c. All redundant elements can be lost by a single credible cause or event such as contamination or explosion.

Equipment appearing on the CIL will be given special attention in establishing hardware specifications and qualification requirements; in manufacturing, inspection and test planning; and in the formulation of operating and maintenance procedures and mission rules.

Implementation

This NHB 5300. 4(1D) provision is adequate for major critical and costly procurement but may not be economical or even required in this depth for alless costly system. In this event, the following may be substituted:

A failure mode and effects analysis (FMEA) shall be performed on the newly designed portions of the equipment. Additionally, as an integral part of conceptual design process, the contractor shall develop FMEA's at the system level to determine possible modes of failure and their effects on the overall system performance. Based on results of the FMEA's, a single failure point summary will be provided to design elements for appropriate consideration in design reviews and trade studies.

10. NHB 5300. 4(1D), Par. 1D301. 4a

Reliability-Maintainability Interface

The contractor shall provide reliability engineering inputs and participation in establishing maintainability criteria and plans to obtain maximum benefit from both design disciplines. Interfacing reliability tasks such as FMEA and redundancy studies shall be coordinated closely with corresponding maintainability trade-offs.

Implementation

This NHB 5300. 4(1D) provision is adequate if it is really needed in a procurement.

11. NHB 5300. 4(1D), Par. 1D301. 4. b

Limited Life Items

The contractor shall identify limited life items, including GFE specified by NASA, which require control from equipment date of manufacture throughout operational use, including storage. Provisions will be made for replacement or refurbishment of hardware after a specified age or operating time/cycle. The contractor shall report to NASA the status of limited life items and waivers on limited life items.

Implementation

This NHB 5300. 4(1D) provision is adequate as stated.

12. NHB 5300. 4(1D), Par. 1D301. 5

Design Review and Readiness Review

The contractor's reliability activities shall include support of internal and supplier design reviews at the system, subsystem, and component levels and NASA design and readiness reviews. This activity shall include an assurance function for compliance of the design to the design criteria defined for the system, subsystem, and component levels. Each engineering change package shall contain a reliability assessment of the effect of the proposed change.

Implementation

This NHB 5300. 4(1D) provision is adequate, but when a requirement for KSC participation is desired, the following may be added:

"Notification shall be made to KSC fifteen days in advance of each Design Review, as to the system element to be reviewed, firm date, time, location and descriptive information on the review in question."

Further tailoring of this NHB 5300. 4(1D) provision may be necessary depending on KSC requirement to participate in subcontractor formal design reviews.

13. NHB 5300.4(1D), Par. 1D301.6

Problem Reporting and Corrective Action

The contractor shall provide a closed-loop system for the reporting of all problems (failures and unsatisfactory condition reports) and the establishment of corrective action for all problems concerning flight, test, simulator, and training hardware where that hardware is representative of flight hardware, GSE, applicable GFE, and spare hardware. The contractor shall be responsible for ensuring that problem reporting and corrective action systems of suppliers will meet the requirements of this section.

a. Problem Reporting - Reporting of problems shall be in accordance with the applicable IRL/IRD.

b. Problem Analysis - An analysis of each problem reported to NASA shall be performed to determine the cause of the problem and to implement adequate measures to prevent its recurrence. Primary emphasis shall be placed on hardware tear down analysis; however, where the cause of the problem is understood or where sufficient prior analysis experience has been obtained, additional hardware teardown for analysis may not be required.

c. Problem Resolution - The contractor shall resolve each problem by one of two methods: closeout or explanation. The contractor shall direct all efforts toward closing a problem in lieu of an explanation, and in no case shall the contractor attempt to "explain" a problem until it becomes impracticable to close the problem.

d. Problem Status - The contractor shall maintain a status on all open problems. The method(s) employed by the contractor in maintaining the status of problems shall be compatible to the contractor's needs as well as those of NASA in responding to requests for information. The contractor shall submit to NASA a listing of all open problems in accordance with the applicable IRL/IRD.

Implementation -

This NHB 5300.4(1D) provision is adequate for large procurements but may be tailored for small ones where IRL/IRD's are not required and when the procurement is primarily for off-the-shelf hardware:

"Problem reporting shall be initiated during all phases of the contractor's effort for newly designed equipment in accordance with paragraph 1D301. 6 of NHB 5300. 4(1D). Problem reporting shall be initiated for "off-the-shelf" items during integration and system tests in the same manner. A copy of each problem report must be submitted to KSC for information."

14. NHB 5300. 4(1D), Par. 1D301. 7

Reporting and Resolving NASA Parts and Materials Problems(ALERTS)

Problems with parts, materials, or equipment which are of mutual concern to NASA and associated contractors are reported by utilizing the NASA ALERT System (NASA Form 863). The contractor shall establish a systematic approach to evaluate and respond to all NASA ALERTS and to investigate, resolve, and document parts and materials problems. Previously published ALERTS will be reviewed to assure that lots, batches, or other groupings of hardware noted as suspect in the ALERT are not used. A summary of previously published ALERTS will be provided by NASA.

a. Investigation - Upon receipt of a problem ALERT, the contractor will initiate an immediate investigation to determine the use significance of the problem item identified by the ALERT in its in-house program and in that of its subcontractors and suppliers.

b. Resolution - Subsequent to the start of acceptance tests when investigation discloses known or suspected usage of the problem item identified in the problem ALERT, a problem report will be issued against equipment having such usage. The reports will be prepared, resolved, and closed in conformance to the method defined in the Reliability Plan.

c. Response - The contractor shall provide a documented response on each ALERT investigation and resolution to NASA in accordance with the applicable IRL/IRD.

d. Contractor-Initiated ALERTS - When the contractor encounters a significant problem with a part or material which may adversely affect equipment, the contractor shall initiate an ALERT and submit it to the NASA ALERT coordinator. The contractor shall not release an ALERT on equipment without prior NASA approval.

Implementation

This NHB 5300. 4(1D) provision is adequate as stated. This provision may or may not be a contract requirement based on criticality and cost of procurement.

15. NHB 5300. 4(1D), Par. 1D301. 8. a. b. c. d. e. f

Electrical, Electronic, and Electromechanical (EEE) Parts and Mechanical Parts Control

a. General - The contractor shall implement a system for controlling the selection, reduction in number of types, specification, application review, analyzing failures, stocking and handling methods, installation procedures, and establishing reliability requirements for EEE and mechanical parts to be used in contract and off-the-shelf hardware.

b. EEE Parts Selection - The contractor and suppliers shall select EEE parts for the contract hardware on the basis of suitability for their application(s) and proven qualification of each to the requirements of its specification. Wherever practicable, items selected shall be already qualified to pertinent specifications, selection shall minimize the number of styles and generic types, and consideration shall be given to industry and Government preferred parts lists (e. g., MSFC document 85M03936). When selecting items previously qualified, the contractor shall devote particular attention to the currentness of data, applicability of basis of qualification, and adequacy of specifications. The results of the selection effort will determine requirements for additional qualification testing and will be the basis for the EEE parts list for the system. (See paragraph 1D301. 8d.) The contractor is fully responsible for the satisfactory performance of each part regardless of the source from which the part was selected or who wrote or approved the controlling documentation.

c. EEE Parts Specifications

(1) Each EEE part shall be controlled by a specification (or combination of specifications) which delineates as a minimum: complete identification of the part; physkcal, environmental, and performance requirements; reliability requirements including inspections and tests for qualification, acceptance, and lot sampling where required; explicit requirements to be satisfied in accepting parts for use in the contract hardware including 100 per cent screen and burn-in; packaging, storage, and handling requirements; traceability requirement; and data retention and submittal requirements.

(2) Where a combination of specifications is used collectively to provide all of the above requirements for a single part type, the detail specification (slash sheet, specification control drawing, etc.) for that part type shall provide detailed cross-reference to all other applicable specifications.

(3) Each specification shall be identified by a unique number, and all specifications shall be subject to a formal system of change control.

(4) All EEE parts specifications shall be available for NASA review upon request.

d. EEE Parts Qualification

(1) Qualification of EEE parts shall be at the part level to the requirements of the applicable specifications. Where adequate qualification data are not available (as determined jointly by the contractor and NASA), the contractor shall be responsible for the development and conduct of qualification tests on parts to determine their adequacy in meeting specification requirements and for the development of criteria to be used in acceptance testing. The contractor shall prepare test plans for those parts which it will subject to qualification testing.

(2) Requalification of parts shall be conducted as necessary to ensure continued control over design, materials, manufacturing processes, and quality controls after initial qualification.

(3) Qualification test plans and test reports shall be in accordance with the applicable IRL/IRD. In the event a part is used which deviates from this requirement, the contractor will submit a waiver request for the deviation.

(4) The contractor shall maintain a data file which identifies the basis and substantiates the status of qualification for each EEE part type used on the project. The file for each part type shall:

(a) Completely identify the part by generic part type and name, controlling specification name and number, common designation (closest commercial equivalent), and manufacturer's name and part number.

(b) Contain a summary of and provide complete cross-reference to all existing data used to substantiate the qualification of the part to the controlling specification. When the basis of qualification is similar to an already qualified part, complete identification and supporting data for the similar part shall be included together with the analysis that establishes similarity.

e. EEE Parts List and Where-Used Parts Lists

The contractor and suppliers shall prepare and maintain a project EEE parts list and composite where-used parts list will be prepared in accordance with the applicable IRL/IRD.

f. EEE Parts Application Review

The contractor (or supplier, if appropriate) shall conduct thorough parts application reviews on the design of each component (black box) at appropriate milestones during its design and development. The results of these reviews will be an input to the design reviews. (see paragraph 1D301. 5). The application of each part shall be examined in light of its rated capabilities in comparison to the design requirements of that application and conformance to the established derating criteria. The derating criteria shall, as a minimum, require a 25 per cent margin between all upper and lower worst-case application stress levels and the corresponding specification stress level for which the part has been qualified. Consideration shall be given to anticipated life requirements, functional and environmental usage stresses, and historic and current failures which have occurred in higher level assemblies on the same system or other projects). Special attention shall be given to any parts used which are not selected from the project parts lists, and the review output documentation shall include or refer to justification for each such usage. The contractor shall take immediate action to correct identified deficiencies.

Implementation

This NHB 5300. 4(1D) provision is adaptable to procurements of major critical systems but may be too costly for small procurements. In this case, the following may be substituted:

"The contractor's reliability organization shall review and concur with all contractor-generated EEE parts design specifications. All specifications shall adequately cover performance and environmental profile requirements, safety margins, and derating factors for the system. These specifications shall be updated as necessary, and shall be subject to NASA review."

16. NHB 5300.4(1D), Par. 1D301.8.g

a. EEE Parts Handling and Traceability

(1) The contractor shall specify minimum requirements for control of storage, stocking, and installation procedures for parts. These controls shall prevent use of parts which may be in a questionable condition and prevent degradation of parts due to environments or faulty manufacturing or assembly techniques.

b. (2) The contractor shall assure that backward traceability data can be provided for all EEE parts. (See paragraph 1D502.) Provisions shall be made to record and retrieve information relating to the specific tests performed, test results, and processes on each lot of parts. Identification of the part manufacturer's production, assembly, or test lot shall be available for each part installed in deliverable end items including qualification and test articles.

Implementation

This NHB 5300.4(1D) provision may or may not be a KSC requirements based on criticality and cost of the procurement. Otherwise itis adequate as written.

17. NHB 5300.4(1D), Par. 1D301.8.h

EEE Parts Problem Reporting and Corrective Action

The contractor shall investigate the cause of each part failure and determine remedial and preventive action. The significance of the failure as related to like parts or materials used elsewhere in the system and the possibility of the occurrence of additional failures shall be determined and documented as part of the problem disposition in accordance with paragraph 1D301-6, Problem Reporting and Corrective Action.

Implementation

This NHB 5300.4(1D) provision may or may not be required as a separate provision from paragraph 1D301-6. It may be used as is if it is necessary for control of EEE parts.

18. NHB 5300.4(1D), Par. 1D301-8.i.

EEE Parts Deviations and Substitutions

The contractor shall establish and maintain an adequate system to monitor and control the use of deviated and substituted parts in contractor, subcontractor, and supplier equipment at all levels of procurement, test, and fabrication. The system shall provide for the prompt identification, reporting, review, and approval/disapproval disposition of the deviated or substituted parts. The provisions of this paragraph will be invoked when EEE parts do not conform to paragraph 1D301-8c, Parts Specification, and paragraph 1D301-8d, EEE Parts Qualification. (See Glossary of Terms for definitions) Subsequent to the CDR, all requests for EEE part changes, deviations, or substitutions shall be submitted to NASA for approval.

Implementation

This NHB 5300.4(1d) provision is adequate but must be invoked only when EEE parts do not conform to paragraph 1D301-8c, Parts Specifications, and paragraph 1D301-8d, EEE Parts Qualification.

18. NHB 5300.4(1D), Par. 1D301-8j.

EEE Parts Control for Off-the-Shelf Equipment

a. EEE parts used in off-the-shelf equipment shall conform to the requirements of paragraphs 1D301-8c and 8d. A where-used parts list in accordance with paragraph 1D301-8c is required. A parts application review in accordance with paragraph 1D301-8f must be accomplished and must assess the adequacy of each part in each application and assure compliance with any applicable NASA restriction on specific parts usage or application. The requirements of paragraph 1D301-8g apply to any new manufacture of equipment to an existing design.

b. Problem reporting and corrective action in accordance with paragraph 1D301-8h and control of substitutions and deviations in accordance with paragraph 1D301-8i are required.

Implementation

This NHB 5300. 4(1D) provision is adequate to invoke in a major procurement if such detailed control is required. Tailoring of the provision may be required in order to attain desired flexibility of control.

19. NHB 5300. 4(1D), Par. 1D301. 8k

Mechanical Parts

MIL-STD 143. "Standards and Specifications, Order of Precedence for the Selection of," shall apply in selecting specifications for standard mechanical parts. Rationale for the selection of company specifications and standards over existing higher order of precedent standards and specifications shall be made available to the procuring activity upon request. This rationale shall include an identification of each higher order of precedent specification or standard examined and state why each was unacceptable.

Implementation

KSC may desire to substitute the KSC approved Parts List (KAPL) for specifying mechanical parts. Otherwise this NHB 5300. 4(1D) provision is adequate.

20. NHB 5300. 4(1D), Par. 1D301. 9

Materials Specifications and Application Reviews

a. Materials Specifications - The contractor shall review design specifications to determine compliance with all required materials specifications. These specifications shall constitute the basis for description and control of all materials to be used in the contract hardware. Where adequate specifications do not exist (as determined jointly by the contractor and NASA), the contractor shall make appropriate recommendations to NASA.

b. Materials Application Reviews - The contractor shall review all materials applications for compliance with flammability and material specifications. The contractor (or supplier, if appropriate) shall conduct thorough materials application reviews on the design of each component (black box) at appropriate milestones during its design and development. Consideration shall be given to anticipated life requirements, functional and environmental usage stresses, and historic and current failure experience (i. e., results of analysis of materials failures which have occurred in higher level assemblies on the same system or project). Special attention shall be given to the continuous review and assessment of flammability and off-gassing properties of materials. This shall include, but not be limited to, material usage, status, test, evaluation, substitution, and verification. The results of these reviews will be an input to the design reviews. (See paragraph 1D301-5, Design Review and Readiness Review.)

Implementation

This NHB 5300.4(1D) provision may require tailoring for KSC procurements since it is primarily written for flight hardware or for GSE to be located in hazardous areas.

21. NHB 5300.4(1D), Par. 1D302

The contractor shall participate in the conduct of the certification and acceptance test program as follows:

a. Certification - The contractor shall monitor and support the certification program established to demonstrate that the design of flight hardware is capable of performing its intended mission. The contractor shall assure that adequate documentation is maintained to substantiate and track activities in meeting certification requirements imposed by contract.

b. Acceptance Testing - The contractor shall review all acceptance test requirements to assure that they are adequate for performance verification and to detect manufacturing defects.

Implementation

This NHB 5300.4(1D) provision may require tailoring to specific KSC requirements. i. e., Final acceptance testing may be required at KSC rather than at the vendor's plant and might require KSC approval of acceptance testing requirements.

RELIABILITY AND QUALITY ASSURANCE AUDIT AND SURVEY PROGRAM

The organizational evolution of the QA/SF survey/audit functions at KSC from 1968 to 1980 was published on October 30, 1980. The following data is important history for that significant period in the Apollo, Skylab, ASTP, and Shuttle Programs:

1968 - 1975

Mail Code	Organization Element	Head
QA	Director, Quality Assurance	J.R. Atkins
QA-PLN	Plans & Policy Office (6 people)	A. Mayes
SF-SUR	Survey Office,1968 (10 people) 1975 (6 people)	G. J. Mayer

In 1975, Safety, QA, and Security were combined into one Directorate, i.e, SF, which resulted in the following:

1975 - 1978

Mail Code	Organization Element	Head
SF	Safety, R&QA, & Protective Services	J.R. Atkins
SF	Associate for S, R&QA, & Protective Services	R.A. McDaris
SF-PRA	Product Assurance Office	R.A. McDaris
SF-PRA-1	Plans & Policy Branch (6 people)	O. Snellgrove
SF-PRA-2	Survey Branch (1975/6 people) 1975/6 people,1978.7 people	T.F. Goldcamp
SF-ENG	Engineering Office(1978/7 people)	A.G. Smith

In 1978, Mr. McDaris retired and Mr. Atkins functioned as SF-PRA Chief. The "Associate Director" function was eliminated.
In 1979, Mr. Atkins had an internal SF reorganization which resulted in the following :

January 1979 - October 1979

Mail Code	Organization Element	Head
SF	Safety,R&QA, and Protective Services	J.R. Atkins

SF-ENG	Engineering Office (took over R&QA Plans and Policy function - 10 people (Resigned)	A.G. Smith
SF-SUR	Survey and Audit Staff (6 people)	T.F. Goldcamp(act.)

In October, 1979, J.R. Atkins retired and W. Rock acted as SF Director until June 1980, when L. C. parker became Director

1979 - 1980

Mail Code	Organization Element	Head
SF	Safety, R&QA & Protective Services	L.C. Parker
SF	Technical Assistant	T.F. Goldcamp(Act.)
SF-ENG	Engineering Office(still has R&QA Plans and policy and audit function (2 people)	A.G. Smith
SF-SUR	Survey and Audit Staff (6 people)	B.L. Jansen

In order to know the extent of activities covered by a typical Safety and R&QA Survey, the following SF Survey Guidelines for the period March 9 - 20, 1980 is provided below:

SF Survey Guidelines, March 9-20, 1981
SF-SUR will survey the following areas:

1. Program Management Documentation

   a. Review for adequacy and up-to-date status:

   KMI 1710.1C, KSC Safety, R&QA Plan and associated KMI's, KHB's,IMI's

   KMI 1150.19, KSC Safety/Health Committee
   KHB 1710.2A, KSC Safety Practices Handbook
   KMI 1710.6, Decontamination, Neutralization, and Disposal of Toxic Propellants, and other Hazardous Liquids
   KMI 1910-PA, Roof Safeguards/Access Control
   KMI 1710.P1A, Demonstration/Test Involving Hazardous Materials
   KMI 1710.13A, Safety Review of KSC TOP's
   KMI 1710.14A, Hazardous Tasks
   KHB 1711.1A, Mishaps Investigation/Reporting
   KMI 1711.1B, Investigation of Accidents/Incidents
   KMI 1712.1D. Reporting of Occupational Injuries by Gov't Employees

KMI 1730.1D, Protective Clothing/Safety Equipment
KMI 5308.1A, Lifting of Hardware
KHB 5310.1A, KSC R&QA Handbook
KMI 5310.9B, Safety Hazard and Rel, Analyses of GSE and Facility, and Integ. Hazards Analyses
KMI 5390.P1B, PRACA
KMI 5310.12C, R&QA Requirements in KSC Procurements
KM18618.9A, TOP Policy
KMI 8838.1B, Fire Protection, Fire Prevention, and Rescue
SF IMI's

b. Check for S, R&QA areas that have no policy or guidance.

2. Configuration Management
Membership on the KSC Level III Configuration Control Board Implementation.

3. Safety

Safety Operations
Hazard Aassessment
Risk Reduction
Safety Audits
Safety investigations (Mishaps/accidents
Procedure Review
DOD Coordination
Safety Review of Waivers, Deviations, Exemptions
Review of Safety Plans/Procedures from Contractors
Review of Contractual Safety Clauses OSHA Requirements

4. Reliability ALERTs
GIDEP
FMEAs/CILs
Safety Hazards Analyses/integrated Hazards Anal.
Reliability and QA Cost Models Associated with Failures and Appraisal/Preventive Actions

5. Nonconformance Reporting (PRACA)
Management and Direction of Overall KSC System
Waivers/Deviations Control and Processing
Prepare/Distribute Trend Data/Status Reports
Planning Effort for Future Programs

6. Safety, R&OA, and Configuration Management Surveys and Audits Procedures

This trail of survey and audit involvement remained in effect until 1989 when Mr. Bruce Jansen was tasked to document concerns regarding manpower levels of survey and audit activities envisioned for the future, including the upcoming Space Station Program. Mr. Jansen's letter to senior KSC management included the following comment:

"KSC has the best SR&QA survey and audit program within NASA as cited by NASA Headquarters during their last three surveys of KSC - 1981, 1984, and 1987." The following survey/audit activity areas were highlighted for KSC implementation into the future:

Reliability Program

1. Reliability Management
   - o Plans/Procedures
   - o Audits

2. Reliability Analysis
   - o FMEA's/CIL's
   - o Design Reviews
   - o GiDEP/ALERT's
   - o Maintainability
   - o Parts/Materials Control
   - o Certification and Acceptance Testing

3,. Problem Reporting and Corrective Action
   - o Reporting
   - o Failure Analysis
   - o Resolution
   - o Status

Quality Program

1. Management and Planning
   - o Plans/Procedures
   - o Audits/Contractor Evaluation
   - o Training, and Certification
   - o Software Controls

2 Design and Development Controls
   - o Design Review
   - o ORMSD o Change Control
   - o Acceptance Review

3. identification and Data Retrieval
    - o Record Center Operations
    - o identification Methods
    - o identification Controls

4. Procurement Controls
    - o Receiving Inspection System
    - o Shipping
    - o QA Involvement
    - o GSE
    - o R&QA Requirements
    - o Records
    - o Vendor Controls
    - o ADP's

5. Fabrication Controls
    - o Planning
    - o Process Controls
    - o Cleanliness/Contamination Controls
    - o NDE
    - o Requests for Supporto Temporary Installations
    - o Inspection Role

6. Inspections and Tests
    - o Planning (QPRD)
    - o Performance and Maintenance
    - o Records and Data
    - o Integrity /Access Control
    - o OMI Distribution
    - o DV Program
    - o TAIR Book System

7. Nonconforming Articles and Materials
    - o Material Review Board
    - o Waiver and Deviations
    - o MRB Holding Area
    - o Repair Controls

8. Metrology Controls
    - o Controls

- o Records
- o Recall System
- o ID and Labeling
- o Standards/Traceability

9. Stamp Controls/Lead Seal Pliers

- o Issuance
- o Security
- o Usage
- o Audits
- o Records

10. Handling, Storage, and Preservation of Materials

- o Controls
- o Marking and Labeling
- o Packaging
- o Age/Shelf Life
- o Surveillance

11. Government Property Control

12. Flight Test/Ground Operations

Biographical Sketch of Author

Frank Childers earned the B.S. Degree in Radio Engineering in 1949, at Indiana Institute of Technology, Ft. Wayne, Indiana. His first job was with the Department of Commerce, Civil Aeronautics Administration (CAA), as a Radio Engineer. He then transferred to the Department of the Army's Redstone Arsenal where he was assigned to Dr. Von Braun's Army Ballistic Missile Agency (ABMA) as an Electronic Engineer.

Frank was an original member of the Missile Firing Laboratory and participated either actively, or in support of, all Redstone, Jupiter, Pershing, and Saturn-Apollo launches.

He served as Chief of the first Instrument Calibration and Standards Lab at Cape Canaveral Army facilities until he was assigned as Chief of Instrumentation Reliability, In that capacity, Frank instituted the first Electrical Instrument Recall System and conducted the first reliability tasks such as Failure Mode and Effect Analysis, Problem Reporting and Corrective Action, Critical parts and Materials Program,and the Inter-NASA Data Exchange Program (INDEX), formerly known as the parts' ALERT System.

In 1972, Frank was certified as a Reliability Engineer by the American Society for Quality Control. Frank's title for most of his KSC career remained as Aerospace Engineer (Reliability) where he gave many hours to developing Program Plans, Procedures, Standards and other publications in the KSC Reliability and Quality Assurance Program. For many years, Frank served as Contract Technical Representative (Reliability) for forty one (41) ground support instrumentation systems during the buildup for the Apollo/Saturn Program.

Frank retired from NASA in 1976 after serving thirty two (32) years in government service. In 1977, Frank was recruited to work for Computer Sciences Corporation in the areas of Reliability and Quality Assurance, Safety, Security, and Employee Training over a new ten-year career.

Frank's writing career began while still employed by NASA with his unpublished booklets, "History of Quality Assurance at the Kennedy Space Center," (1974), and "Kennedy Space Center Beginnings," (1986). After retirement Frank continued writing for publication as follows:

The Biography of Dr. William S. Hughlett, of Cocoa, Florida. Dr Hughlett served forty (40) years as a Medical Missionary to the Belgian Congo, (Published,1985).

History of the Cape Canaveral Lighthouse, (Published,1983).

Faith in Space, 170 page book about our space scientists', engineers' and astronauts' belief in God and in an orderly universe, (Published,1997).

American Society for Quality Control

Frank McDowell Childers

a member of this Society, has satisfactorily fulfilled the requirements established by the Education and Training Institute of the Society for professional attainment in Reliability Engineering and is, therefore, certified as a

Reliability Engineer

David C. Leaman
Director, Education and Training Institute, ASQC

David S. Chambers
President

Dated: January 28, 1972

Certificate Number R822

Certification of Training with the American Society of Quality Control (ASQC)

(2)

AMERICAN SOCIETY FOR QUALITY CONTROL

161 WEST WISCONSIN AVE. • MILWAUKEE, WIS. 53203 • TEL: 414 272-8575

January 13, 1972

Mr. Frank M. Childers
33 Little John Lane
Rockledge, Florida 32955

Dear Member:

The Officers and Board of Directors of the American Society for Quality Control extend their congratulations to you on your advancement to the grade of Senior Member in the Society.

Your becoming a Senior Member not only reflects continued interest in the field of quality control but also represents recognition of your dedication by the fellow members of your Section through its Examining Committee.

This important step that you have taken will open many vistas for you, not only in Society activities, but in the fields of science and engineering.

We look forward to your continued participation in the activities of your Society.

Sincerely yours,

Robert W. Shearman
Administrative Secretary

RWS:JT:bg

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