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# KSC Facilities Status and Planned Management Operations

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## ABSTRACT

This is a status report on the facilities and planned operations at the Kennedy Space Center that will support Space Shuttle launches, the first of which is now scheduled for late 1979. The facilities are essentially complete, with all new construction and modifications to existing buildings almost finished. Some activity is still in progress at Pad A and on the Mobile Launcher, due to changes in requirements, but is not expected to impact the launch schedule. The installation and testing of the ground checkout equipment that will be used to test the flight hardware is now in work. The Launch Processing System is currently supporting the development of the applications software that will perform the testing of this flight hardware.

The Shuttle Program is unique to past manned space programs in that very tight budgetary constraints have been imposed in an effort to keep the costs low. For KSC, this means adopting a philosophy of launch-to-cost. In an era of routine space flight, this presents a very real challenge to management; the necessity of controlling costs while maintaining tight schedules. An overview of how this management challenge is to be met will be presented.

## INTRODUCTION

The conversion of KSC facilities to support efficient and economical operations in the era of the Space Shuttle is nearing completion. This massive, complex task was assigned to KSC because studies indicated that support systems could be converted more economically than new ones could be built at another location. Therefore the driving force behind the KSC effort from the beginning has been the necessity of providing adequate physical facilities and accompanying support systems at minimum cost. This required the maximum utilization of existing buildings, both on KSC territory and on Air Force property on Cape Canaveral, and the construction of two major new facilities and several minor ones.

The two largest new structures are the Shuttle Landing Facility (SLF) and Orbiter Processing Facility (OPF). Major modifications were required to the Vehicle Assembly Building, Launch Pads A and B, the old KSC parachute facility, and Hangar AF on Cape Canaveral. Several other buildings, including the Operations & Checkout Building and Spacecraft Assembly & Encapsulation Facility No. 1, were also modified, but are part of the payload processing system and not within the scope of this paper. Several other buildings, primarily existing spacecraft processing facilities, will be utilized for Shuttle payloads in much the same manner as for expendable vehicle spacecraft, and require little or no modification.

At present, no major problems are known which could impact the planned First Manned Orbital Flight in November, but the schedule allows for no delays in delivery of flight hardware or unexpected problems in checkout. In general, the scheduled delivery of ground support equipment and spares supports the need dates. The largest current backlog of work is in the software area, for both procedures and applications programs. The primary problems are in the areas of computer resources and validation time to debug the programs. The most intricate single computer function, the Launch Processing System (LPS), is operational, and overall performing very well. The hardware and vendor software for the LPS are meeting all design expectations.

With some dummy components and early flight items now being processed through preliminary stages in the Shuttle launch cycle, plans must be finalized to conduct the simplified checkout and launch operations planned as an essential part of the Shuttle program. The extensive planned utilization of computers, including those on the orbiter itself, and the required speed of turnaround operations on the ground, to a certain extent dictate the type of management program that will be most effective.

The automated management aids being developed must smoothly merge into the various activities and mechanical functions, and must be capable of coping with the dynamic stresses inherent in the activation of new or modified facilities, as well as the preparation of ground support equipment to support the new generation of flight hardware. Above all, management must ensure that the operational procedures developed are capable of receiving and relaunching the Space Shuttle on the allotted timeline, at the planned cost, and with full adherence to all reliability and safety constraints.

## COMPLEX 39 FACILITIES

### Shuttle Landing Facility

The SLF runway is complete, and has been in use for limited airplane traffic for some time. The Mate-Demate Device which attaches or removes the Orbiter from its 747 carrier (Fig. 1) is complete and functional. The major SLF innovation in aeronautics, the Microwave Scanning Beam Landing System (MSBLS), which lands the orbiter under ground control, has recently been tested, and performed well. A specially equipped airplane from Dryden Flight Research Center was used to certify the MSBLS at KSC. The towway from the runway to the orbiter's first stop, the OPF, is also complete and ready.

### Orbiter Processing Facility

The OPF consists of two high bays, a low bay, and an office annex (Fig. 2). The brick-and-mortar work is complete, and all equipment installed in the low bay and in high bay 1. (The OPF is capable of processing two orbiters simultaneously, but high bay 2 will not be needed before 1981.)

The largest and most complex item in a highbay is the set of access platforms, which effectively surround the orbiter while in the OPF. These platforms provide two rolling bridges, each with two independently movable trucks with a personnel bucket at the bottom of vertically telescoping arms. They also provide flip-up platforms at several levels to provide access to various parts of the orbiter. High Bay #1 is now being phased over to NASA/Rockwell control.

### Vehicle Assembly Building

High Bays 1 and 3 of the Vehicle Assembly Building (VAB) have been modified to accommodate the Space Shuttle configuration, including removing the top Extendable Platform in each bay and reworking the remaining four as necessary to form an air-tight seal against the Shuttle components. The Platforms were removed for the modification work, but are now back in place. Some relatively small changes to the steel structure were needed, and have been completed.

High bays 2 and 4 have completely new roles to play in processing the Space Shuttle, and have been modified accordingly. The Extendable Platforms have been completely removed from high bay 2 (they were never installed in high bay 4). A series of workstands has been installed in each bay, beginning at ground floor level, to checkout and process the external tanks and solid rocket booster (SRB) segments (Fig. 3). Each bay has stands for two tanks and a sizable number of SRB segments. The structural work for this extensive system of stands is complete, and they are ready to function.

The low bay of the VAB has also been reconfigured to process the Shuttle. The cells on the west side have been reworked to provide a series of workstands to handle the non-propellant parts of the SRBs, including the nose cones, frustums, aft skirts, and forward skirts. This necessarily includes handling the parachutes that will later lower the SRBs to the ocean. Other facilities behind the checkout cells provide paint and insulation booths, special exhaust systems to support them, and other facilities. These are also complete. The cells on the east side of the low bay will serve primarily as storage areas for SRB components, except for one cell which will store orbiter main engines and component parts. Few structural modifications were required.

### Crawler-Transporters and Mobile Launcher Platforms

The two Crawler-Transporters perform virtually the same function in the Shuttle era as in the days of Apollo, and in an almost identical manner. They are capable of continued operation without modification. The Mobile Launcher Platforms are reconfigured Mobile Launchers, formerly used as transportable stacking platforms for Saturn vehicles. They will perform a very similar function for the launch of a Space Shuttle. The most visually obvious change is the removal of the tower, topped by its jib crane, which gave the former configuration a height of over 400 feet. The single engine exhaust hole has been changed to three, to accommodate both the orbiter engines and the two SRBs, and two tail service masts and six water quench nozzles have been added. One Platform is ready except for some deck work still in progress, and a contract was recently let to convert the second one. As with several other facilities, one platform will adequately support activities at KSC through 1980.

Launch Pads 39A and 39B

Pad 39A has been extensively reconfigured to support Shuttle launches. The tower, formerly on a Mobile Launcher, has been permanently installed, in a shortened form, at the pad. It is now called the Fixed Service Structure (FSS). Adjacent to the FSS is a large new device, the Rotating Service Structure (RSS) (Fig. 4). Except for clean-up work both new items are structurally complete, and the installation of GSE is on schedule and will support the planned arrival of the first Space Shuttle.

The RSS rotates through 120 degrees, from the fully retracted position to contact with the orbiter payload bay doors. It pivots off a tall supporting structure anchored off the southeast corner of the FSS, and is connected to the FSS on several levels by bridges that move with the main structure. The opposite side of the RSS is supported by a truss assembly that reaches to the ground, where it rests on two eight-wheel, motor-driven trucks. These move along a circular twin-rail system installed flush with the pad surface, and supply the motive power to move the RSS.

The primary function of the RSS is to provide access to the Space Shuttle on the pad, particularly the payload bay compartment. Those payloads processed through KSC in the vertical mode--and this includes most of the communications, weather monitoring, and scientific satellites that have formed the bulk of KSC launches to date--will be installed in the orbiter at the pad, via a specially-equipped room in the RSS. The RSS is probably the largest and most structually unique addition to KSC facilities required to support the Space Shuttle.

Other modifications at the pad include the installation of a sound suppression system, which includes a 300,000 gallon tank that supplies water to the six nozzles mounted on the Mobile Launcher Platform, and to a series of other nozzles installed at the pad. All will deluge the area where the exhaust flames from the orbiter and the two solids impact the pad, both cooling the surfaces and greatly reducing the acoustic levels generated by rocket exhaust. Although some tests are still in progress, the structural work for the sound suppression system is complete.

Various other smaller additions or changes to the pad, such as the reconfiguration of the flame deflectors, the installation of the RSS track across the flame trench, etc., are all complete. With GSE installation going well, Launch Pad A is nearing operational status.

The contract for similar modifications at Launch Pad B was let within the past few months, and preliminary work is in progress. Pad A alone can support the Space Shuttle pre-operational launch schedule through 1980.

## LAUNCH SUPPORT FACILITIES OFF COMPLEX 39

Solid Rocket Booster Disassembly Facility

One major facility which is an integral part of the Space Shuttle processing flow, but is not located at Complex 39, is the SRB Disassembly Facility on Cape Canaveral. When the spent SRB casings, parachutes, and frustums are recovered at sea (the nose cone alone is expendable), they are brought to the disassembly facility by two specially equipped recovery vessels, each handling one complete booster. A slip has been constructed in the Banana River east of Hangar AF especially to handle the returning SRBs. The slip is equipped with mobile gantry cranes to lift an SRB from the water and install it on four standard-gauge tracked dollies connected to form a long train. The slip is operational and the gantries and dollies have been assembled and are undergoing preliminary operations.

The SRB safing area is also operational, and the building has been completed for the first wash (before disassembly) operation (Fig. 5). The AF hangar, where the dolly train rolls after the first washing, has been extensively modified for SRB disassembly, including the installation of two rail systems from the slip into the building. Most support systems installation, such as gaseous nitrogen, electrical power, etc., are complete, but the access stands to support disassembly operations are still in work. After separation, each of the four major SRB segments remains on one of the four dollies, until loaded onto a truck for transport to the VAB, and loading on a special railroad car for the return to the manufacturer's plant for repouring of propellant.

A second wash building east of Hangar AF processes the frustums and skirts through their cleaning cycles. These items are then taken to the low bay of the VAB for final processing, and refurbishment as necessary for another launch. The second wash facility is also virtually complete.

Parachute Refurbishment Facility

The three main SRB parachutes and the drogue chute are recovered at sea by being wound around special reels on the recovery vessel. These reels are delivered to the parachute facility, which was at one time the Gemini parachute facility. They are unwound, washed, air-dried, and repaired as necessary, all in the horizontal mode (Fig. 6). The latter is an innovation that should find widespread usage, since most parachute users have previously required tall buildings to wash and dry the fabric in the vertical position.

A major addition to the parachute facility, to equip it for its new role, is complete, and all support equipment has been installed and tested. The parachute facility is now ready to handle the much larger and heavier SRB parachutes, including repair of tears and replacement of shrouds, as necessary.

Several other facilities off-site from Complex 39 will also be involved in Shuttle processing activities, such as the Hypergol Maintenance and Checkout Facility in the KSC industrial area, and the usual support services provided by organizations located in other parts of KSC.

## MANAGEMENT OF COMPLEX 39 OPERATIONS

The new requirements, special facilities, and unusually high degree of interaction between computers, mechanical devices, and human beings pose new challenges to the efficient management of Complex 39 facilities and the operations conducted in them.

Despite the complexities involved, management must create and maintain an environment conducive to the effective and efficient performance of individuals and groups, to ensure that each Space Shuttle mission--once the STS system is fully operational and routine checkout status is achieved--is processed through KSC on time and within budget. A management philosophy proven in the Apollo program is currently being used to drive this effort during the transition from site activation to the operational flight test phase. This concept is "Management by Exception." The Rockwell Space Division-Launch Operations group at KSC is responsible for initial launch operations.

Rockwell utilizes the accepted essentials of management, i.e., planning, organizing, staffing, directing and controlling to achieve the stated objectives. Near the beginning of the current program Launch Operations developed a Work Control Plan, based on both aerospace experience and air carrier maintenance techniques, and applied it to the Space Shuttle ground turnaround requirements. This plan breaks down into nine functions (Fig. 7), which provide the building blocks for task accomplishment.

## PLANNING AND ORGANIZATION

The stepping stones used to bring Launch Operations into the transition phase from site activation to flight hardware processing are straightforward and orderly. Requirements applicable to KSC Shuttle processing were delineated; plans were conceived for KSC site activation; vertical flight testing and operational uses of the Shuttle were set forth; technical documentation for operations, maintenance and inspections were developed; the scheduling system for ground support equipment facility activation and operational use were defined; and visibility was given to support requirements.

Contractor Engineering

Contractor engineering personnel at KSC have received the task of preparing the organizational level checkout procedures, including development of the applications software. This software is prepared, using a high-order language, for automated checkout and troubleshooting operations. Test Preparation Sheets (TPS) are produced by engineering to cover the final hook-up of ground support equipment and unplanned one-time type tasks, such as special tests and inspections. This same engineering task force performs system level (premate) test management, with NASA approval, and shares the responsibility with NASA for integrated testing. Element engineering obtains the resolution to real-time design problems that occur during maintenance and checkout runs, designs special test equipment required for Shuttle processing, and coordinates, prepares, and works as a member of the approval cycle for MOD incorporation instructions.

Operations Planning and Scheduling

The Operations Planning and Scheduling organization provides visual clarity to programmed site activation activities, systems/GSE validation, and flight hardware testing and checkout. This group operates an automated recall maintenance system which includes the scheduling and status of periodic maintenance, calibration, proofloading, and hydrostat testing of designated items of equipment.

Quality Assurance

Quality Assurance has the task of compiling and keeping up the Quality Planning Requirements Document. Selected data from the document is used in the production of detailed work authorization procedures, and provides for the incorporation of predetermined verification sequences in procedures to be accomplished by the technicians. This method assures standardized work, and reduces the inspection load of QA personnel. Additionally, the audit of procedures by QA personnel will be implemented as the disciplines stabilize and the number of mandatory changes diminishes. To provide centralized control and visibility for all systems quality and reliability problems, a problem action center will be established at KSC.

Safety. Safety provides detailed criteria for the preparation and review of procedures involving multiple or catastrophic hazards, perform hazard analyses, assist engineering in hazard reduction through recommended use of devices or alternate procedures, and promote an active industrial safety program. Access control to Shuttle system hardware is limited through the emphasis on personal and personnel discipline, and surveillance.

Material and Logistics. This organization provides the necessary equipment, assemblies, and/or parts necessary for the progression of work, from initial installation to sustained equipment operation. This is accomplished through existing NASA supply channels, element supply, or, when authorized, open purchase.

Configuration Management. This organization maintains two accounting systems. The Baseline Accounting and Reporting System is used at the program level, and the Configuration Verification and Accounting System (CVAS) is used by Rockwell. Both systems are mechanized. The CVAS is used to provide as-designed to as-built configuration status of the orbiter vehicle, and selected items of ground support equipment. Acountability is maintained for changes affecting spares, software, modifications, and previously approved procedures.

Ground Crew Training. This function is implemented during the initial phases of the program, through a systematic definition and achievement of personnel training, skill, and proficiency verification. Continuity of ground operations training is maintained by close coordination among the technicians, operations and systems engineers, quality assurance, and safety personnel.

DIRECTION AND CONTROL

The STS project, as conceived, will operate as a spaceline, the equivalent of a modern airline in function and management, transporting cargo and people to and from space on a regularly scheduled basis. The success of each mission depends on proper preparation of the vehicle and cargo during the ground turnaround operation. A 100% serviceability rate is scheduled for OV-102 and its sister ships. Therefore it is of paramount importance to effectively and efficiently deservice, checkout, replace defective material and components, and reservice the vehicle, to meet the programmed 100% utility rate of STS flight hardware.

Many factors must be considered in attempting to achieve a launch-to-cost performance guide. These include budget allocations, funding, type of contract (and control permitted within it), and the degree of technical and logistical support available. Many different considerations must be evaluated in order to successfully direct and control such a large project. Therefore it is essential that a method of achieving that direction and control be developed, and aggressively employed.

Management By Exception

A simple, straightforward method successfully employed by Rockwell Launch Operations at KSC is "Management by Exception." This philosophy provides the means of zeroing in on problem areas, or on other operations which are not meeting prescribed standards. By establishing a system of information gathering that defines the problem, provides an insight into the cause of the problem, prompts verification of the information received, promotes immediate and decisive action and requires follow-up, attention can be centered on the areas that need it most. Activities meeting required standards can proceed with only a minimum of attention from management.

Two essential mechanisms are used to effect the desired results. One is the Central Information Center, which consists of a series of scheduling rooms displaying all major activities. The other is a simple 8 by 11-inch form that addresses open work outstanding against an authorized engineering procedure.

Central Information Center. The Central Information Center (Fig. 8) displays Rockwell activities in simple bar chart form, to provide visual clarity of an item's specific schedule and status. A curser line is used to show the "as of" time for statusing purposes, and two basic colors are used to depict an item's condition. Green is used for on-schedule, and red to denote a problem situation that is a constraint to scheduled progress.

Flash Notice. In addition to the red color indicating a problem on a status board, the exception is further detailed by the use of a "Flash Notice" (KSC Form 4-286). This notice will usually be generated at the work site by the individual who services the open item status report (OISR) for the item in question. The notice contains the date it was issued, the initiator of the notice, the site location, the system involved, a brief description of the problem, the intermediate corrective action taken (if any), and the identity of the responsible individual and department. This information, displayed in the Central Information Center (and at the originating site), provides the responsible individual(s) with a visual cue to the deficiency, and brings it to the attention of management at whatever level is needed. The OISR is the basic tracking system for all disciplines that generate working paper, perform the tasks, and close out the working paper when the task has been completed.

Test and Inspection Record. The record itself is opened when a work authorizing document is written against an item and entered into the Test and Inspection Record (TAIR). The scheduler then initiates an entry into the Open Item Status Report reflecting the item's identity, related system, the constraint which the procedure is being worked against (usually a test procedure), and a brief description of what the work authorization will accomplish. This task is reviewed by management at the level responsible for implementing the work. If there are no constraints to the task being worked immediately it is scheduled for a specific time, and the start and stop dates are entered into the appropriate task constraints column of the OISR. It is then tracked until a change in status occurs, or the task is closed out. If a change occurs that requires additional engineering, or parts, or both, appropriate notations are made in the TAIR by the individual reporting the change. The scheduler notes the situation in the OISR under the appropriate task constraint column. If the situation is not rectified within a prescribed time, the scheduler produces a Flash notice against that item and responsible individual.

Weekly Review. A weekly review of all information displayed in the central information system is held by the top four levels of management. This review readily brings to the surface those problems most critical to progress. The details are discussed, decisions made, and action assigned as necessary to alleviate the problems. Those problems that require attention by agencies other than Rockwell are carried forward to the appropriate parties for resolution. An active follow-up is maintained, initiated by the site scheduler, up to whatever level of management is required to resolve the problem.

Tracking and Monitoring. The detailed tracking and monitoring of all open work provides visibility to management at all concerned levels, through the red-green statusing of schedules, the issuance of Flash notices, and the distribution of copies of the open item status report to key personnel each week.

The central information center, under this plan, becomes a commnications focal point wherein the General Manager builds his knowledge of problems confronting his organization, and is provided with detailed information concerning the problems by his management team. Top-level decisions are made from current data, with actions placed on priority tasks and follow-up processes initiated. Follow-up action of previously assigned tasks is a normal part of the operation.

In addition to this problem solving technique, real-time and near real-time situations calling for top-level management attention are resolved by the interaction of the various levels of leadership in Rockwell, thereby making timely decisions based on established policy and/or rational means of solving the problem at hand. The nine functional disciplines described in the Work Control Plan are the fulcrum points for the checks and balances necessary for a success-oriented organization.

In short, planned tasks are formulated into scheduled events through timely engineering releases and the availability of people (technicians), parts (logistics and material), and access to the equipment where the work is to be performed. Quality and safety efforts provide standards and guidance. Configuration management maintains an up-to-date status of the as-built assembly. Personnel training provides the means to increase skills and maintains the required records and certifications. Altogether, these functions create a smoothly working organization.

## GENERAL MANAGEMENT TECHNIQUES

The effective implementation of zeroing in on "problems" requires the indoctrination of all hands in what is expected of them under various known job circumstances. This is accomplished through opera-

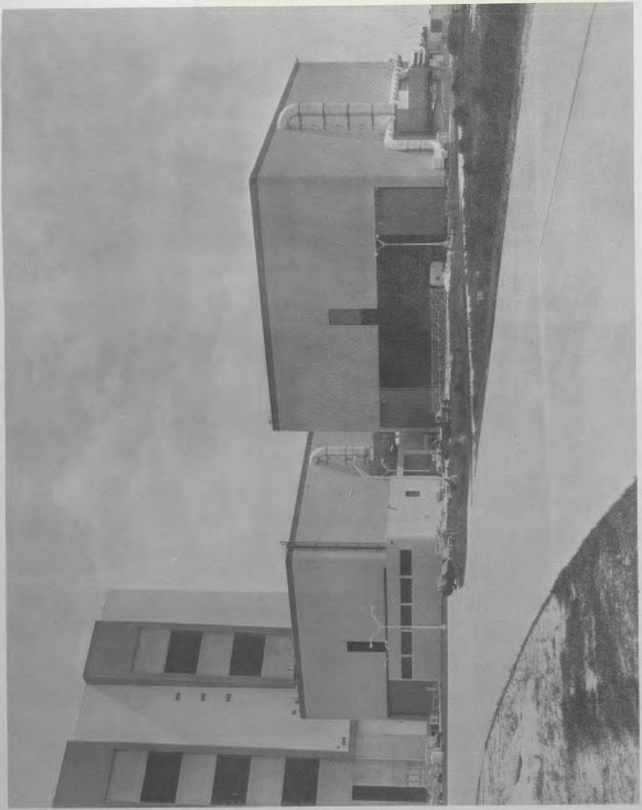


Figure 2. Exterior View of the Orbiter Processing Facility

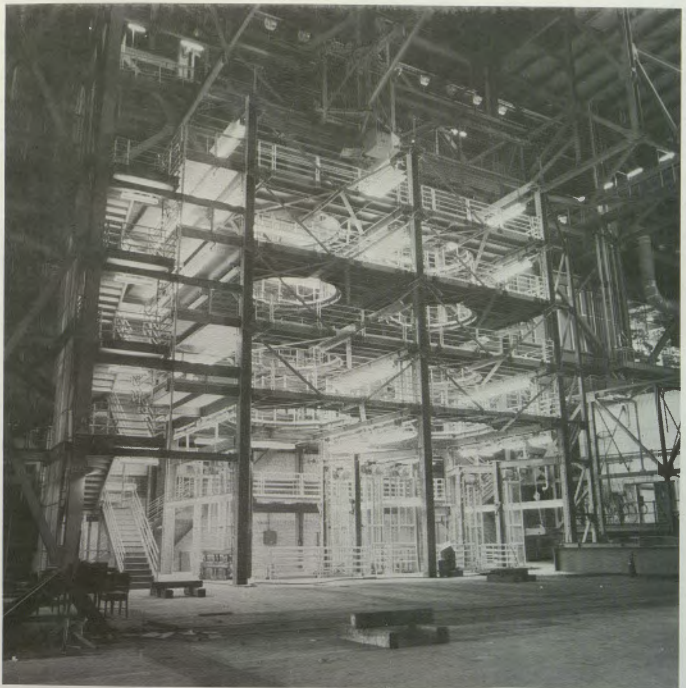


Figure 3. Solid Rocket Booster Workstands in VAB High Bay 2

Figure 4. Fixed Service Structure and Rotating Service Structure at Pad A, Launch Complex 39

Figure 5. First SRB Wash Facility, Showing Rails Leading to Hangar AF in Rear

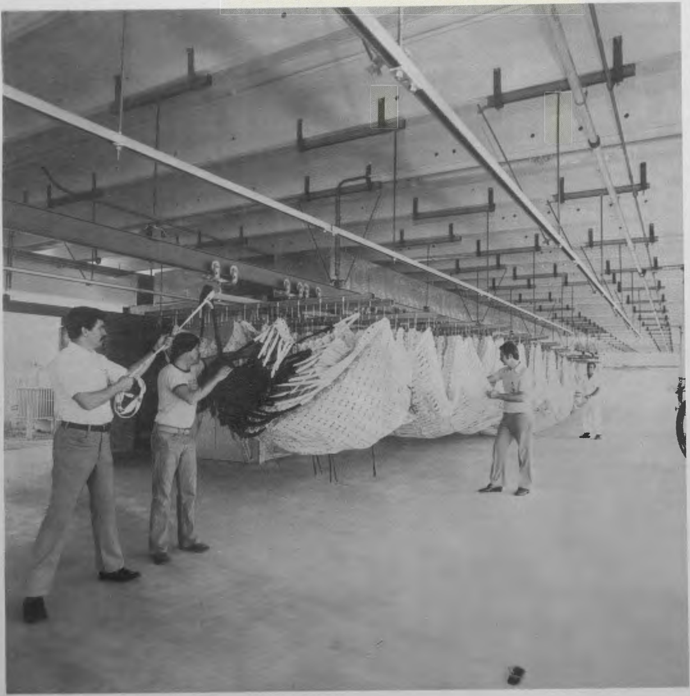
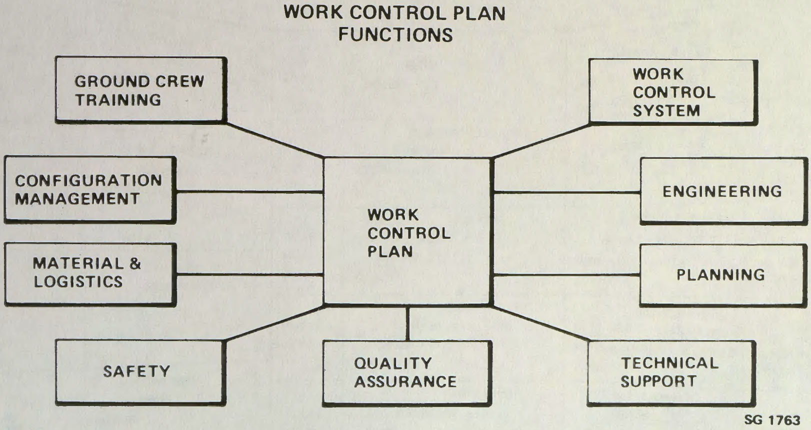


Figure 6. Parachute Suspended Horizontally from Rail in SRB Parachute Refurbishment Facility




'Figure 7. Outline of Work Control Plan Functions

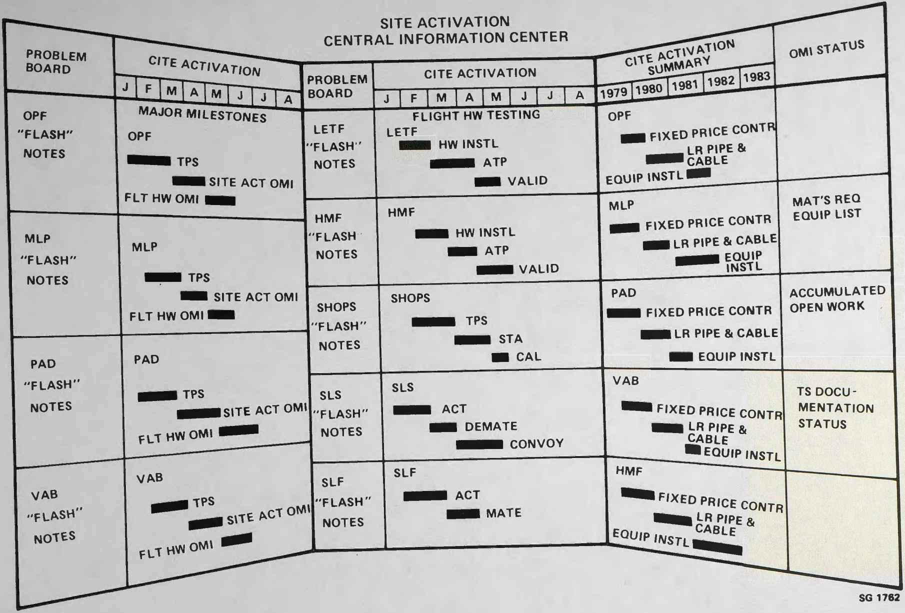



Figure 8. Typical Planned Status Display at Information Center