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DESIGN REQUIREMENTS FOR SRB PRODUCTION CONTROL SYSTEM

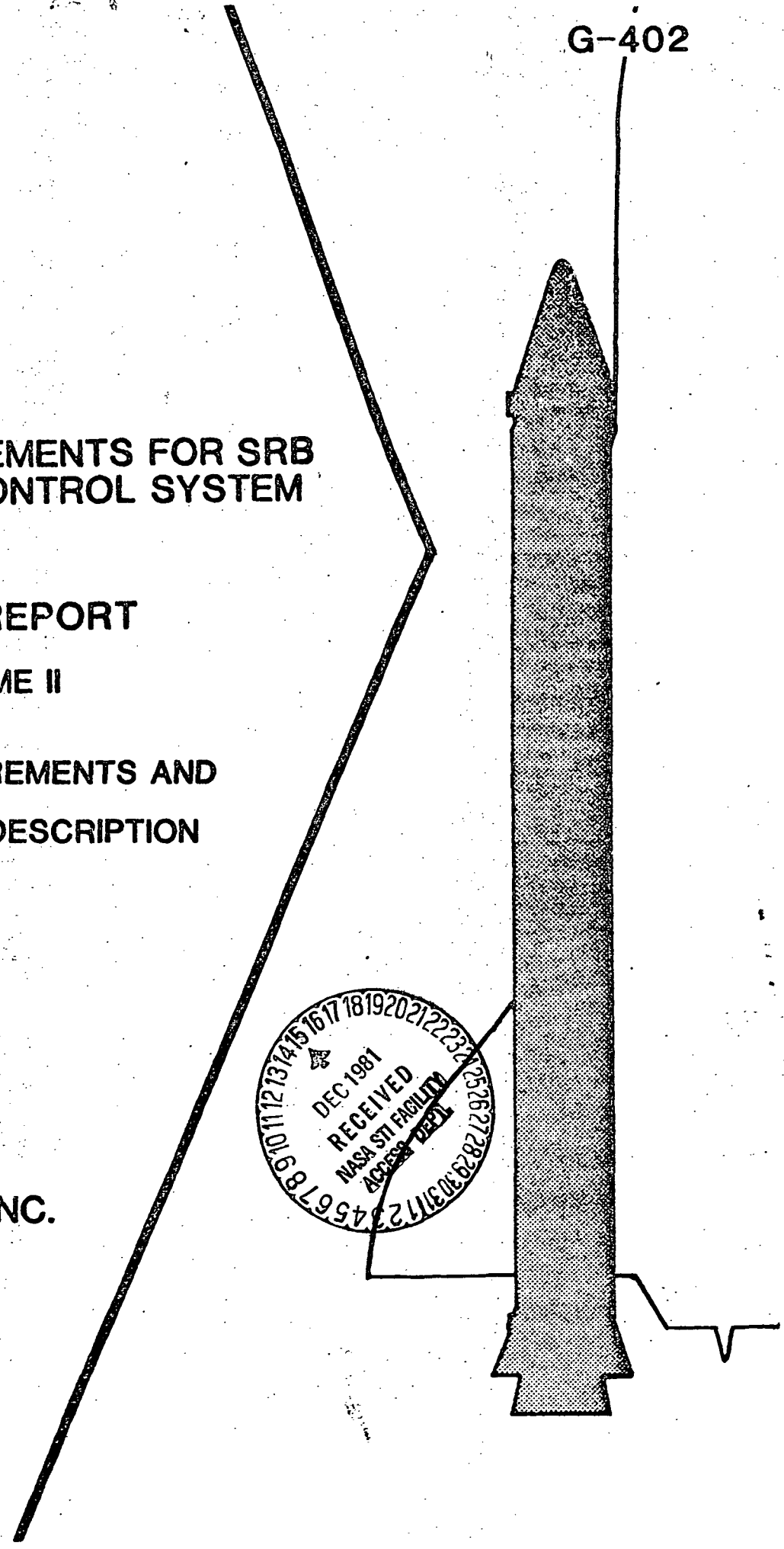
FINAL REPORT

VOLUME II

SYSTEM REQUIREMENTS AND CONCEPTUAL DESCRIPTION

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DESIGN REQUIREMENTS FOR THE SRB PRODUCTION CONTROL SYSTEM

VOLUME II

SYSTEM REQUIREMENTS AND CONCEPTUAL DESCRIPTION

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INTRODUCTION

In the development of the business system for the SRB automated production control system, special attention had to be paid to the unique environment posed by the space shuttle. The issues posed by this environment, and the means by which they were addressed, are reviewed in this section.

First, there is a discussion of the change in management philosophy which will be required as NASA switches from one-of-a-kind launches to multiple launches. Second, the implications of the assembly process on the business system are described. These issues include multiple missions, multiple locations and facilities, maintenance and refurbishment, multiple sources, and multiple contractors. Third, the implications of these aspects on the automated production control system are reviewed. This includes an assessment of the six major subsystems, as well as four other subsystems. Finally, some general system requirements which flow through the entire business system are described.

MANAGEMENT PHILOSOPHY

Manned space flight has in the past been in one-of-a-kind disposable launch vehicles and space craft. The management systems which have evolved to support this business environment are directed at:

1. Elimination of risk, ensuring astronaut safety at at any cost.

2. Assurance of design integrity through detailed control techniques which include:

- (a) Tight design change approval control.
- (b) Configuration control with "delta" reports.
- (c) Detailed flightreadiness review process.

3. Tracking of materials and assemblies through inspection, storage, work-in-process and assembly into the "as built" configuration.

Shuttle operations will require a shift in management philosophies. The reasons for this shift are the stability of the launch vehicle design, the reuses of launch vehicle and shuttle craft and the increasing emphasis on cost effectiveness. This shift in management philosophy will support the following mission objectives:

- 1. Ensure crew safety.
- 2. Contain value added per flight.
- 3. Stabilize design for multiple mission component use.
- 4. Reuse or refurbish assemblies and components as rapidly as possible.
- 5. Maintain the minimum manufacturing resources required to meet launch schedules.

This shift is a reorientation to a manufacturing management philosophy for NASA and the SRB contractor. This manufacturing

management philosophy will include the following elements:

1. Customer service. Emphasis will be directed at achieving integration timetables with delivery of products of acceptable quality. Customer service would be monitored through:

- (a) Promise date performance with regard to product delivery commitments to integration activities. Key deliveries in the SRB process would be aisle transfer, stacking completion, and clean and disassembly dates.
- (b) Delivered product acceptance analysis reports such as rework requirements or work remaining reports. This would apply to refurbishment, assembly, stacking and cleaning and disassembly activities.

2. Productivity, utilization and cost control. These elements define the cost effectiveness of manufacturing resources employed and require the following:

- (a) Balanced resource availability plans to resource requirements; e.g., balance the mechanical technicians available to the operations scheduled which require mechanical technicians.
- (b) Facilities design optimization.
 - (1) Use of cost effective facilities, buildup stands, and equipment.
 - (2) Facilities layout optimization, particularly in critical facilities such as the Hot Fire Test Facility.
- (c) Facilities schedule loading; i.e., time required in the facility versus time available.

- (d) Manpower requirements planning and schedule loading.
- (e) Materials requirements planning, in the form of LRU requirements by serial number, by date, as well as the back-scheduling of the refurbishment required to provide these serially numbered LRUs by the required date, within the configuration constraints.
- (f) Standard costing and variance reporting, in the form of standard or expected cost per mission versus actual cost.
- (g) Operations performance tracking, in the form of standard refurbishment operations and standard time per operation.

3. Manufacturing risk management. Risk can be managed through the proper design of the production control system. Some techniques used to manage risk are:

- (a) Contingency capacity planning of facilities, manpower, and materials availability, in the event of such things as technical skill disqualification, minor or major accidents at facilities, etc.
- (b) Calculated risk of stock-outs or shortages and buffering risk with safety stock or spares. This is particularly critical due to the unknown condition of retrieved SRBs as subsequent missions are planned or readied.
- (c) Exception alerts highlighting any significant deviation from planned activity. This is a technique needed to identify potential bottlenecks such as unavailable GSE as early as possible.
- (d) Priority action management systems. This is a method to

expedite critical work through the refurbishment and subassembly facility. The high volume of schedule juggling needed is a requirement which an automated scheduling system must accommodate, due to the large number of serially numbered parts in the system at one time.

4. Rebuildable SRB Management Control. SRB refurbishment places unique requirements on the production control system used. These include:

- (a) Facilities, manpower, and materials planning based on best estimate of needs. These estimates may be reasonably accurate averages over time but are inaccurate for the refurbishment of an individual SRB.
- (b) Management control and engineering compatibility of hybrid mixtures of new and refurbished components.
- (c) Cost tracking hybrid SRBs.

5. Evolution of Design Flexibility. Although design stability is desirable, design emphasis will evolve through the following phases:

- (a) Flightworthiness design.
- (b) Weight control design.
- (c) Cost minimization design.

6. High Operations Performance and Cost Visibility. Orientation to a "least value added per flight" management philosophy requires tracking of resource productivity and comparisons to the planning assumptions used. Typical productivity

reports are:

- (a) Operations budgeting and variance reporting, initially by flight and SRB; later by activity area, labor skill level, and major component; e.g., the aft skirt.
- (b) Facilities utilization reporting.
- (c) Manpower productivity performance reporting, by refurbishment and subassembly Work Authorization Document (WAD), by work team, and by component.
- (d) Inventory planning and performance tracking reports, by LRU, bulk material; e.g., cork; and by subsystem.
- (e) Tools and GSE planning, scheduling and performance reports.
- (f) Actual and standard cost reporting, by mission, SRB, and major component.
- (g) Value added reporting per flight and SRB.
- (h) Delivery promise reporting at key delivery times; e.g., aisle transfer.

7. Coordination with Shuttle Control. The interdependence of multiple contractors requires that integration performance be tracked. Some of these performance elements are:

- (a) Multiple contractor schedule interdependencies.
 - (1) Delivery performance in the form of providing services; e.g., tube cleaning, at the scheduled time.
 - (2) Hazardous operations, such as ordnance ring installation.

- (3) Shared GSE by several sub-contractors.
- (b) Contract performance feedback.
 - (1) Product quality insofar as rework time and cost.
 - (2) Delivery performance and progress status.
 - (3) Actual SRB and per-flight cost compared to estimated or "standard".

MULTIPLE MISSIONS

Unlike previous manned missions undertaken by NASA, the Space Shuttle Program is based on the reuse of two of the three major modules in the project. One of these modules, the two Solid Rocket Boosters, are recovered after each flight, cleaned, inspected, tested, refurbished, and reassembled for use in a future flight. This multiple mission provision coupled with the principle of minimum value (cost) added to each subsequent flight requires the following considerations to be addressed by the business system:

1. Provide the ability to support multiple design effectivities across the planning horizon.
2. Provide different planning horizons dependent upon the lead or acquisition time of the resource; e.g., technical manpower, facilities and SRB components. The different planning horizons include:
 - (a) Long-range manpower planning (five years or program remaining).
 - (b) Short-range manpower planning (six months by week).

- (c) Facilities and work center planning (five years or program remaining).
- (d) Facilities loading (six months by week).
- (e) Materials by commodity class (by POPs or program remaining).
- (f) Materials by item (by vendor lead time).
- (g) Critical GSE (by POPs).
- (h) GSE loading (six months by week).

3. Provide the ability to support hybrids of new and refurbished subassemblies, parts and components.

4. Provide for the eventual stabilization of hardware design while maintaining the flexibility of providing multiple design changes during the initial phases of the program.

5. Support a launch schedule going from two flights per year to in excess of 50 flights per year (for two locations).

6. Provide for action reporting on an "exception" basis which, in critical cases, will require management action needing manual (human) decisionmaking.

MULTIPLE LOCATIONS

Due to the eventual expansion of the STS program, it is anticipated that actual refurbishment and assembly must be accomplished at more than one location. Currently, Kennedy Space Center in Florida and Vandenberg Air Force Base in California are the anticipated locations.

Because of this requirement the following considerations must

be taken into account:

1. Data files used for all planning, scheduling, tracking, performance monitoring, and job costing must be identical at the start of each day, where shared records are needed. However, this is not to imply that the work centers, actual SRB configurations, physical working facilities or work/material routings must be identical.

2. Refurbishment and assembly at each location will be controlled at that location and therefore, the planning, control, and tracking will be discrete at that location.

3. The POPs will be used with the master mission profile to "drive" the system at each location, based on the discrete launch schedule for each location.

4. In order to maintain minimal safety stock inventories, it is anticipated that parts, components and subassemblies may need to be transferred from one location to the other. This could provide for shared safety stock and perhaps reduce the cost of such safety stocks. Therefore an on-line, real-time data communication link between the two locations is recommended.

5. The system must provide access to all history files of parts, testing results, and actual refurbishment and assembly activities at both locations.

6. It is anticipated that due to the huge amounts of data storage required, a mainframe computer will be necessary at each location.

MULTIPLE FACILITIES

Based upon the existing facilities located at KSC, considering the distance between facilities as well as the physical size of each facility, the following requirements are noted:

1. At least one and possibly multiple data collection terminals will be needed in each facility. One "possible exception" to this requirement might be at Pads 39A and 39B.

2. Based on current plans the following types of activities have been identified for the above requirement:

- (a) Refurbishment/Subassembly.
- (b) Testing and Inspection.
- (c) Assembly.
- (d) Material storage (short and long term).
- (e) Disassembly and Cleaning.
- (f) Receiving.

3. Specific locations (at this time) include the following locations where data collection would be recommended:

- (a) Hangar AF.
- (b) Hangar N.
- (c) VAB (High and Low bays).
- (d) Hot Fire Testing.
- (e) VAB-1N4 and 1F4.
- (f) Pads 39A and 39B (Possibly).
- (g) Parachute facility (minor).
- (h) Battery Lab.
- (i) Gyro Lab.

4. An "intelligent terminal" is recommended for use as the data collection device referred to above. The exact terminal type; i.e., data collection or minicomputer, will be specified in the computer systems requirements.

5. Status of material must be known at each work center for each shift. A work center would be equivalent to the current area where major activities occur, such as, aft skirt build-up stand, forward skirt buildup stand, Hangar N test rings, MLP (by levels), etc. In some cases a work center may be associated with an entire facility; e.g., the Hot Fire Test Facility; but if multiple work areas are developed for multiple activities and tests to take place simultaneously, each could be considered a work center.

6. Several work centers may be combined into work center groups, using one data collection terminal.

7. Data collection devices at each work center group do not necessarily have to be tied together "on-line" within each facility, but do require linkage at the end of each shift.

8. Data collection devices at work center groups of sufficient data entry volumes will require the ability to produce hard copy of labor to be performed, material or GSE requirements, or routing information.

9. Data collection devices used at work center groups will accept information about work progress on a "real-time" basis throughout the shift.

10. These devices will provide status reporting information to the complex (KSC or VAFB) mainframe at the end of each

shift (batch).

11. These devices however, must provide "real-time" file information from the mainframe computer.

MAINTENANCE AND REFURBISHMENT

(a) Flight Hardware

In order to ensure in-flight safety and operational success, a detailed (refurbishment) schedule has been developed by NASA. This refurbishment schedule can be summarized as follows:

1. Organization Refurbishment. Refurbishment performed in-place on vehicle subsystems and maintenance performed on related support equipment in direct support of the turnaround flow. Organizational refurbishment/maintenance includes scheduled and unscheduled, preventive and corrective actions required to inspect, calibrate, service, replace, in-place repair and modification, and reverification of subsystems and associated components.

2. Intermediate Refurbishment. Refurbishment performed in direct support of organizational refurbishment and maintenance, and involves disposition, repair, service, calibration, modification, and verification of items removed during organizational refurbishment. Its phases normally consist of calibrating, repairing, or replacing damaged or unserviceable parts, components, or assemblies.

3. Depot Refurbishment. Refurbishment performed by designated sources; e.g., manufacturers, USAF Air Material Areas, and NASA Development Centers, etc., because equipment, facilities,

or skills are not economically available at the intermediate maintenance levels. Depot refurbishment includes providing technical assistance to the intermediate refurbishment levels.

In addition, all refurbishment functions are classified into different types: unscheduled, scheduled, or servicing tasks.

1. **Unscheduled Refurbishment.** Unscheduled refurbishment encompasses two types: corrective action and postflight inspection. The corrective action includes the investigation and correction of discrepancies noted during the previous flight. Further corrective action tasks will be initiated after completion of visual postflight inspection. The function will be accomplished by providing a high level of confidence for system performance evaluation and fault isolation to a single defective line replaceable unit (LRU) in the minimum amount of time and with a minimum of special support equipment. Although in-place repair may be used for simple refurbishment acts, the primary method will be replacement of the faulty LRU with a like serviceable unit. Following LRU replacement, the subsystem function will be re-verified. Isolation of LRU malfunctions and verification of repair will be completed by replacement of the most readily replaceable subassembly level of equipment. Following repair, the operating condition of the LRU will be verified and necessary alignments and adjustments will be completed before the LRU reaches the status of a ready-issue spare.

2. **Scheduled Refurbishment.** Consists of a preplanned program of refurbishment with particular emphasis on retaining

solid rocket hardware in specified condition by providing systematic inspection and detection, to prevent incipient failures. The tasks are scheduled on the basis of flying time, equipment operating time or cycles, and/or calendar time.

3. Maintenance Servicing. Servicing, within the allocated portions of the operational turnaround cycle, includes the routine ground operations required to prepare the vehicle for launch and mission requirements. These functions include replenishment of all expendables or consumables and life support elements.

Finally, in order to fully define the parameters of a comprehensive refurbishment concept, equipment replacement has been grouped into three categories:

1. Predictive Items. Removal and replacement of an item is based upon the item's life having approached or achieved a previously defined limit. The assessments of the limit are made at intervals determined by the item's failure characteristics and may consist of inspections, measurements, tests, or any other means not requiring teardown or removal of the item from the vehicle.

2. Fly-to-Fault Items. This classification is reserved for particular items which are not mission essential, do not affect flight safety, and that remain in place until an assessment of the item's condition indicated that removal is required. The item must fail in a random fashion and detection of the item's malfunction requires no expenditure of refurbishment or maintenance man-hours.

3. Scheduled. Removal and replacement of these items is based solely on a time-dependent failure mode, regardless of their condition when removed. The scheduled replacement classification will include only those items which cannot be classified as predictive or fly-to-fault. The removed item undergoes a tear-down inspection and/or overhaul.

Based on the above summary of SRB refurbishment requirements, as well as other observations made during the audit phase of this engagement, the following are business system requirements:

1. Ability to track parts, components, and subassemblies by part/serial number and level and type of refurbishment required/performed.
2. Ability to flag required parts refurbishment scheduled but not yet performed.
3. Ability to sort by type or level of refurbishment required/performed, keying on discrete part number/serial number.
4. Ability to maintain permanent file of actual versus planned refurbishment performed by type and level.
5. Ability to accumulate refurbishment performed by part/serial number and to compare to estimated service life determinations; by number of previous flights and by number and type of previous refurbishment activities.
6. Ability to differentiate part, component, and sub-assembly items by part/serial number in inventory based on the actual refurbishment performed.

(b) Ground Support
Equipment

Due to the critical nature of certain types of GSE, it is necessary to identify and control such GSE as an integral part of the overall business system. While it is recognized that a computer package may not include the scheduling and control of "maintenance equipment" such as GSE or buildup stands, in its mainline operation, a future modification or enhancement will probably be necessary to incorporate this "function" into the system. Even then, a great deal of manual manipulation will be required due to "shared" use of some GSE by contractors other than USBI.

Therefore, either a fully manual or semiautomated system will be necessary to provide scheduling and tracking capabilities within the overall system environment. Key requirements are identified as follows:

1. Provide information as to specifically what GSE is required during scheduled refurbishment or assembly across a several-week time horizon.
2. Identify what "condition" of GSE is necessary in order to provide the required function.
3. Identify what "condition" the GSE is actually in and determine the disparity (if any) between the actual and required condition.
4. Provide estimated schedules of servicing or maintenance requirements to critical GSE in order to provide

such GSE at the time it is "required" per the computer system schedules. This might include calibration, proofloading or normal preventive maintenance.

5. Flag GSE which is not in a serviceable state, with enough lead time to perform GSE proofing or service prior to the estimated requirement time.

6. Maintain on a permanent file specific information related to GSE which is required in order to provide uninterrupted serviceability and functional operation. Included might be:

- (a) Type of service required.
- (b) Dates of past service.
- (c) Estimated future service requirements.
- (d) Problems, discrepancies, or modifications which have taken place in the past.
- (e) Other specific considerations.

MULTIPLE SOURCES

Due in part to the number of vendors supplying components to the SRB project, as well as the long and variable lead times and cost of individual parts, the following required capabilities of the system have been identified:

1. Provide current on-order information to procurement by the following key classifications:

- (a) Subsystem or commodity classification.
- (b) Vendor.
- (c) Bill of material effectivity.

- (d) Need date versus promise date.
 - (e) Parts in need of expediting.
2. Track vendor performance data by individual vendor and summarize performance by vendor class or LRU or subsystem level code.
3. Report performance data of vendors. This may be specified in the following areas:
- (a) Quality, including "acceptable" deviation from specifications.
 - (b) Actual cost versus budgeted cost.
 - (c) Promise date versus need date.
 - (d) Actual receipt date versus promise date.
 - (e) Overall material flow continuity. This is particularly important in providing aisle transfer and launch date integrity. This might be expressed in terms of "number of delays caused by vendor", etc.
 - (f) Vendor production milestone performance, in terms of achieving a LRU refurbishment or replacement within the time specified.

Other system considerations are included in the "Purchasing" section of this business system requirement document.

MULTIPLE CONTRACTORS

Recognizing that several prime contractors and numerous subcontractors are involved in the STS project, the following requirements have been identified:

1. USBI will require a system responsive to their needs

as well as NASA's needs, but not necessarily interface directly with systems of other contractors, for example Thiokol.

2. Some type of interface will be required, however, and it is anticipated that such interface will be manual in nature.

3. Since SRB refurbishment and assembly schedules are, in part, contingent upon not only the overall mission profile and POP, but are also contingent upon detailed operating schedules of other contractors, communication and coordination between USBI and these other contractors is of major importance, and must be given the level of authority required to initiate action.

4. The overall system (manual procedures and computer systems) must, therefore, be able to respond easily to changes in schedules, material requirements, and resource requirements based on conditions which arise outside of USBI's scope or control.

5. It is anticipated that this response will be based on manual inputs and overrides by USBI management.

6. Resources to be shared with other contractors will be scheduled using the USBI automated production control system but are subject to a high degree of variation and "schedule non-compliance" due to unknown, or unforeseen circumstances resulting from problems caused by other contractors.

7. It is anticipated that NASA will provide, in addition to general guidelines and procedures, a specific scheduling system for "shared resources" in order to reduce the slippage impact among contractors.

MASTER SCHEDULING/
RESOURCE PLANNING

The system must be able to:

1. Interpret the mission launch schedule into an aisle transfer schedule for major components such as aft skirt, frustum, etc.
2. Determine, if these major components can meet aisle transfer requirements.
3. Schedule refurbishment of major components and assemblies.
4. Assign a specific refurbished and new major assemblies to a specific SRB flow; i.e., effectivity control for hybrid SRBs.
5. Determine ability to produce to launch and to aisle transfer schedules.
 - (a) Determine time-phased resource requirements such as:
 - (1) Facilities by critical work center, e.g., Hot Fire Test Facility.
 - (2) Manpower by labor certification, e.g., Electrical Technician by specified skill certification.
 - (3) Materials by commodity classification or critical component.
 - (b) Match resource requirements against a time-phased resource availability plan and report resource capacity information. This resource capacity information will include identification of overcapacity resources, and

underutilized resources. For example, if for one month hot fire facilities require 120% of the planned capacity, then an action report will identify this as a potential bottleneck facility.

- (c) Balance resource requirements and the resource availability plan. This will require adjustments to the requirements schedule and the availability plan. Adjustments to the resource requirements schedule may involve backing off the aisle transfer date to an earlier date, thereby moving peak capacity demands to an earlier time period which has available capacity. Adjustments to the resource availability plan may include the reallocation of resources with excess capacity to resources with deficient capacities; or may include the reduction of resources having excess capacity; or the acquisition of resources having deficient capacity.
- (d) Determine financial requirements needed to produce. This will include costing of resource requirements to determine SRB costs, and will also include costing of the resource availability plan to determine future budget requirements implicit in the mission launch and aisle transfer schedules. The determination of financial requirements demanded to meet schedules will be the basis of Operations Budgets, which will budget materials, manpower, facilities and overhead, and will monitor key performance milestones. These performance milestones will include:
 - (1) Launch compliance.

- (2) Aisle transfer compliance.
 - (3) Facilities acquisition, or disposal.
 - (4) Manpower skill certification buildup.
 - (5) Materials acquisition by class or critical component.
 - (6) Safety limitations.
- (e) Consider SRB recovery loss projections.

6. Reschedule for changes with minimal data manipulation. This will require identification of schedule change needs and resource change needs which are caused by a launch or aisle transfer schedule change, while not permitting the system to "overreact". For example, minor or insignificant changes such as a one-day lag in scheduled refurbishment, should not create an alert for action, but instead automatically provide for a "net-change".

7. React quickly to planning exceptions such as:

- (a) Losses of SRBs on recovery.
- (b) Launch schedule changes.
- (c) Shutdown of work centers.
- (d) Financial cutbacks.

8. Simulate "what if" situations and determine impact

on:

- (a) Launch schedule compliance capability.
- (b) Aisle transfer schedule compliance capability.
- (c) Resource requirements.
- (d) Resource availability plans.

(e) Operations budgets.

These "what if" situations may include changes in:

- (a) Launch schedules.
- (b) Aisle transfer schedules.
- (c) SRB recovery loss rates.
- (d) Manufacturing and assembly cycle times.
- (e) Design configuration.
- (f) Resource usage rates.
- (g) Resource availability plans.
- (h) Resource costing data.

9. Project resource plans and operations budgets for multiple years. This will allow automation of the POPs process and will facilitate total program cost projections, currently performed by BOSIM.

MATERIALS REQUIREMENTS PLANNING

The system must be able to:

1. Project time-phased material requirements over a two- to three-year materials planning horizon. These projections will require:

- (a) A producible master schedule depicting SRB flow launch schedules, and new or refurbished major assembly aisle transfer schedules.
- (b) Material release offset lead times to stage the release of materials for each assembly.
- (c) A structured bill of material for each SRB effectivity to be produced.

- (d) A forecasted attrition bill of materials which depicts the probability of replacing any component during the major subassembly/refurbishment process.
- (e) A bill of materials which reflects the manufacturing process rather than the engineering design logic. This may include creation of additional levels in the bill which reflect stages of assembly or testing. This is often accomplished by the use of pseudo bills in the engineering bill, thereby emulating the manufacturing process flow of materials.

2. Compare the projected materials requirements against planned inventory availability to determine net material requirements. This netting will require:

- (a) An inventory control system which has the following features:
 - (1) Item reservations against explicit requirements.
 - (2) Receipt planning by due date.
 - (3) Linking (pegging) of planned receipts or on-hand items to explicit requirements.
 - (4) Reorder policies for manufactured items.
 - (5) Refurbishment/subassembly and stacking cycle times.
 - (6) Reorder policies for purchased items.
 - (7) Purchasing lead times.
 - (8) Maintained safety stocks.
 - (9) Nonactive item locations for exclusion from available stock.

- (b). Differentiated types of net requirements. These will include:
 - (1) Purchase requisition recommendations grouped by commodity class and consolidated by item for economic ordering of materials.
 - (2) Recommended shop orders for one item at a time to facilitate effectivity control and configuration management. However, the timing of the shop orders will be consolidated to achieve production economies of scale.

3. Track rescheduling by the degree of order flexibility.

This will require three types of orders:

- (a) Planned orders. These orders do not yet have resources committed to them. Therefore rescheduling is done for any change in material requirements.
- (b) Firm orders. These orders have resources committed but are not released. Therefore rescheduling is done if material requirements changes are significant.
- (c) Released orders. These are purchase orders released to vendors and shop orders released to dispatching. These orders are expedited or deexpedited rather than rescheduled.

4. Firm up the "as designed" configuration for an SRB flow effectivity. This will require freezing design changes for a specific flow or mission. This "frozen" configuration will be used as the benchmark design for comparison to the "as built" configuration. This will not mean, however, that the design must be frozen across three years.

5. Facilitate effectivity and configuration control.

This will be accommodated by:

- (a) Maintaining "as designed" and "as built" configuration data on each serialized item in inventory, if modifications have been made to this item since serialization was initiated.
- (b) Identifying all engineering changes required to upgrade effectivities of each serialized item.
- (c) Tracking "as built" data as each serialized item is used in a sub-assembly.
- (d) Identifying item/assembly cross reference to parent drawing as well as location on drawing.
- (e) Identifying substitution possibilities for flightworthy effectivity alternatives to a specific item number.
- (f) Tracking engineering change status and milestone performance.
- (g) Allow assembly of hybrid SRB flows of a mixture of new and refurbished and of multiple design effectivities. These mixtures must be well documented for flightreadiness reviews and will have prior approval from flightworthiness inspectors and/or from a design compliance review board.

6. Facilitate ease of material requirements manipulation. This will be improved by:

- (a) Automated bill of material requirements explosion and inventory netting.
- (b) On-line real-time adjustments.
- (c) Net change systems logic.

CAPACITY REQUIREMENTS
PLANNING/RESOURCE
LOADING

The system must be able to:

1. Extrapolate the time-phased materials requirements for manufactured and assembled items into a detailed resource capacity loading by week over a six-month horizon. The resources loaded will include:

- (a) Work centers and facilities.
- (b) Labor skill certifications.
- (c) GSE and tools.

2. Identify surplus and deficient resources. This will highlight capacity work centers or labor skills and identify all shop orders which may cause that resource capacity to be exceeded. Capacities will be based on a "practical" capacity for each resource, but reports will include a theoretical maximum capacity.

3. Combine preventive maintenance schedule resource loading with that of shop orders, but allow preventive maintenance orders to have alternative scheduling priorities. For example, orders could be:

- (a) Mandatory at a particular time.
- (b) Mandatory before any other work using a specific work center or GSE.
- (c) Discretionary when resources become available.
- (d) Discretionary with increasing priority.
- (e) Other priorities.

4. Block labor certification time from "available for production". This will be required for:
 - (a) Sick and personal time contingencies.
 - (b) Department meetings.
 - (c) Vacation.
5. Project capacity loads based on best estimates of refurbishment needs.
6. Adjust resource requirements based on work-in-process decisions. For example:
 - (a) Routing changes to alternate operations or work centers. This will probably remain a manual activity.
 - (b) Routing changes to added operations and resource requirements. This would include test process sheets, problem reports or discrepancy reports.
 - (c) Time compression or expansion decisions.
 - (d) Appended routing segments based on refurbishment test results. These results will list:
 - (1) Further tests or operations to be performed.
 - (2) Line replaceable units to be replaced.
 - (e) Appended routings required to rework substitute effectivities up to the required effectivities. This will include routings to incorporate engineering orders.
7. Structure routings to coordinate with manufacturing bills of materials.
8. Base resource requirements on predetermined standard

times established in design, and flag potential problems caused by actual variances from standard.

9. Block multiple work centers for one operation.

This is required for work centers near hazardous operation, such as ordnance installation.

10. Distinguish between functional labor departments working in parallel on the same operation, such as mechanical and electrical technicians.

11. Track rescheduling needs by the degree of flexibility available. This will require three types of orders:

- (a) Planned orders.
- (b) Firm orders.
- (c) Released orders.

12. Adjust shop order schedules and routings easily.

These adjustments will include:

- (a) Rescheduling.
- (b) Cycle time compression or expansion.
- (c) Alternative routings, operations, or work centers.
- (d) Appended routings.
- (e) Resequenced routings.
- (f) Freezing shop orders in a semi-finished status.

13. Trigger materials rescheduling for shop orders rescheduled during capacity planning or during shop floor management activities.

14. Track "as planned" and "as built" routings for each shop order.

15. Facilitate ease of capacity load manipulation.

This will be improved by:

- (a) Automated capacity extrapolations from material requirements and work-in-process refurbishment, subassembly, assembly, and disassembly cleaning orders.
- (b) On-line real-time adjustments.
- (c) Net change systems logic.

SHOP FLOOR MANAGEMENT/
DISPATCHING

The system must be able to:

1. Support a dispatching function. This function will perform the following activities:

- (a) Develop dispatch schedules which have had resource availability checked through capacity requirements planning activities. These dispatch schedules will include all work-in-process orders and a two-to four-week queue of work to be released, by work center.
- (b) Reverify inventory and resource availability. This activity will require:
 - (1) Materials inventory availability checks.
 - (2) GSE and subcontractor availability commitment checks.
 - (3) Labor certification availability plan checks.
- (c) Hold "shop orders pending scarce/unavailable resources".
- (d) Report expedite requirements for:
 - (1) Material shortages.

- (2) GSE nonavailability.
 - (3) Labor certification scarcity.
 - (4) Shop orders needing shop floor expediting or deexpediting. This would use a "critical ratio" schedule analysis concept.
- (e) Release shop floor paperwork prior to the time work is to start. This paperwork will include:
- (1) Drawing reference numbers and work authorization document numbers so that hard copy support documents can be assembled for the job packet.
 - (2) Routing operations sheets to control the standard operation sequence flow.
 - (3) Labor control cards to requisition a specific labor certification for a specific operation on a shop order, and to record actual labor certification time on that operation.
 - (4) GSE requisitions to acquire support needed for a specific operation on a shop order, and to record actual time that GSE was dedicated to that operation.
 - (5) Inventory requisitions or picking lists to kit materials needed. These picking lists will be only for on-hand items. Shortages and staged releases will be held for a later picking list release. If shortages are deemed to cause a work stoppage then the shop order would be held back, the shortage expedited, and the job packet held back. Picking lists may be released for

prekitting to allow facility in-transit times, but would not be used to circumvent the need for inventory accuracy.

- (f) Schedule work by shift. This is required to facilitate:
 - (1) Labor performance data accumulation, and reporting.
 - (2) Hazardous operation scheduling, e.g., fire department, etc.
 - (3) Shop floor dispatching for shift management.

2. Support integration contractor information needs.

For example:

- (a) Hazardous operation scheduling.
- (b) Subcontractor scheduling.
- (c) GSE scheduling.
- (d) Schedule integrity for SRB readiness and aisle transfer schedule compliance.

3. Facilitate ease of dispatch schedule manipulation and resource availability checking. This will be improved by:

- (a) Automation.
- (b) On-line real-time adjustments.

4. Disburse dispatching activities to shop floor dispatchers located in multiple facilities.

OPERATIONS TRACKING

The system must be able to:

1. Track shop order status. This will require the following information:

- (a) Recording operations completed.
- (b) Accumulating labor to an operation.
- (c) Adding operations required for rework or problem reports, or for refurbishment not originally anticipated.
- (d) Flagging shop orders held because of inventory shortages or scarce resources.

2. Gather data to support performance reporting. This will include:

- (a) Actual labor by worker, labor certification, operation, and shift worked.
- (b) Duration of time a work center is dedicated to an operation on a specific shop order.
- (c) Duration of time any GSE is dedicated to an operation or a specific shop order.
- (d) Changes in standard labor hours or operation duration for changed or alternate operations.

3. Support configuration management control requirements. This will include:

- (a) Benchmarking "as designed" material configurations of a planned effectively for a specific shop order.
- (b) Benchmarking "as planned" work routing linked to the "as designed" material configuration.

- (c) Accumulating shop order "as built" material data such as:
- (1) Assignment and installation of subassemblies and components by serial number.
 - (2) Multiple level pegging of materials to components, of components to subassemblies, of subassemblies to major assemblies to SRB flows by effectivity.
 - (3) Assignment and installation of lot or batch controlled materials.
 - (4) Component drawing installation location by cross-reference to drawing locator codes.
- (d) Accumulating shop order "as built" routing data such as:
- (1) Labor hours, by certification, applied to an operation.
 - (2) Sequence of operations performed.
 - (3) Operations added to refurbish, and reasons for altered sequences.
 - (4) Operations added for TPS/PR/DR work authorization documents.
 - (5) Test results reports of any testing operations.
 - (6) Operations deleted and reasons.
 - (7) Alternative operations used and reasons.
 - (8) Repeated operations or series of operations and reasons.
 - (9) Flightworthiness status codes.
 - (10) Disposition decision codes.

4. Disburse operations tracking activities to strategically located data control stations on the shop floor. These would be similar to the current TAIR stations.

5. Produce exception reports requiring immediate action. These may include:

- (a) Critical work centers down.
- (b) Labor deficiencies.
- (c) GSE nondelivery or nonperformance.
- (d) Other shop floor problems.
- (e) Material deficiencies.

PERFORMANCE MONITORING/
STANDARD COSTING

The system must be able to:

1. Report productivity performance. This will include weekly, and monthly reports on:

- (a) Labor productivity by:
 - (1) Worker.
 - (2) Labor certification.
 - (3) Labor department.
 - (4) Operation performed.
- (b) Work center utilization by:
 - (1) Percent of standard operation duration time.
 - (2) Percent of available capacity.
- (c) GSE utilization by percent of operation standard duration time.

- (d) Shop order performance against standard for:
 - (1) Labor productivity.
 - (2) Work center utilization.
 - (3) GSE utilization.
- (e) Standard cost variance analysis. This is a comparison of standard versus actual cost data.

2. Summarize detail data upon the close of a shop order. This will require updates to:

- (a) Shop order summary configuration "as built" information.
- (b) Labor summary information.
- (c) Work center summary information.
- (d) GSE summary information.
- (e) Subassembly, assembly, major component, SRB, and flight summary information.

3. Record detail information after summarization in a low activity media, such as microfiche.

4. Update operations budget tracking information.

This would track actual costs and milestone performance against operations budgets. This would use frozen standard bills of material and routings as the budgeting baseline. Variance analysis would then reflect the same assumption base used in development of the operations budgets.

INVENTORY MANAGEMENT
AND CONTROL

The system must be able to:

1. Perform serial-numbered item tracking, and support data cross-reference control. This requirement includes the following elements:

- (a) Link serial numbered item to its unique item history. This history includes:
 - (1) Current "as built" information.
 - (2) Prior "as built" detail for previous flights or rework.
- (b) Monitor effectivity status. This would include:
 - (1) "As built" and "as designed" information.
 - (2) Delta lists.
 - (3) Engineering changes required to upgrade to a desired effectivity.
 - (4) Routings and work authorization documents associated with engineering changes required.
- (c) Allocation of serialized items to a specific shop order of a defined effectivity. This allocation would be determined prior to picking or kitting inventories, and would be based on "least value added" to achieve flightworthiness compatible with effectivity of the SRB flow. This requires "explicit pegging" in an automated production control system. For example, SRMs must be used in "cast lots".
- (d) Monitor item status. This status will include:
 - (1) Availability to production.

- (2) Allocation to specific shop orders.
- (3) Held for inspection, rework, or disposition.
- (4) Location in inventory stocking area.
- (5) Location for items returned to vendors.
- (6) In transit.
- (7) Location in work-in-process operations.
- (8) Location installed of an item serial number which was manufactured per a numbered shop order.
- (9) Anticipated return to stock date.
- (10) Anticipated return to stock disposition.

2. Perform lot control of nonreusable materials (e.g., fasteners). This would include quantities of a lot disbursed to a specific shop order.

3. Monitor item location control. This requirement tracks the physical location of each item. For example:

- (a) Moves among storage locations within an inventory stocking area.
- (b) Moves across multiple facilities.
- (c) Moves to work-in-process operations.
- (d) Moves to launch ready status.
- (e) Moves to recovery, clean and dismantle status.

- (f) Moves to refurbishment/subassembly.
- (g) Moves to disposition or inspection locations.

4. Monitor inventory accuracy. This will include the following inventory control features:

- (a) Exception tracking. Exceptions indicate errors in inventory data such as:
 - (1) Location errors.
 - (2) Effectivity errors.
 - (3) Flightworthiness status errors.
 - (4) Quantity errors.
 - (5) Serial number or lot control number errors.
 - (6) Part identification or tagging errors.
 - (7) Picking errors.
- (b) Cycle counting. Cycle counting is used to:
 - (1) Validate and measure inventory accuracy and measure performance of responsible persons.
 - (2) Ensure recovery of mislocated items. This requires zone or area counting with item and serial number identification.
- (c) Audit trail analysis. This facilitates backtracking to find inventory errors.

5. Manage item life. This is required to achieve maximum usage of items over a limited life. Factors influencing

item life may include:

- (a) Shelf life in storage (e.g., oil seals).
- (b) Time life expectancy (e.g., batteries).
- (c) Flight life expectancy.
- (d) Inspection constraints for specific items or serialized parts.
- (e) Failure history by item or item effectivity groups.

6. Establish safety stocking levels. Safety stocks will be set to offset definable risk levels caused by:

- (a) Attrition forecasting error.
- (b) Quality errors or inspection item rejection rates.
- (c) Launch schedule flexibility.

7. Simplify inventory transaction input requirements.

For example:

- (a) Receiving.
 - (1) Purchased item receipts from vendors will have a copy of a purchase order release located in the receiving area. Only exceptions to planned receipts need to be recorded.
 - (2) Moves to inspection or from inspection will be entered through a preprinted move tag with flightworthiness status and item location entered.
 - (3) Receiving from recovery will be accomplished by reactivating "as built" data with a spent status code. Line replaceable unit disposition tags would also be preprinted

for refurbishment inventory transaction simplification.

(b) Disbursement.

- (1) Allocate specific item by serial number to a shop order prior to kitting.
- (2) Picking lists organized by picking route of least distance and identifying serial numbered items.
- (3) Picking lists released only for items in stock (no shorts) and time phased to shift requiring the items.
- (4) Refurbishment activity matrix identifying parts kits to accomplish refurbishment to flightworthiness status of a planned effectivity.

8. Monitor inventory management performance. This

includes:

- (a) Inventory analysis. This would be a comparison of actual cost versus standard cost of items maintained in inventory.
- (b) Inventory turns. (To be determined by NASA projecting costing).
- (c) Inventory shortage valuation. This is the total cost at standard of items shorted as a percent of items disbursed. Shorted items should be recounted each week to include the impact of shortage duration.
- (d) Inventory overage valuation. This is the total cost at standard of inventories not required by production to be initiated within two to four weeks. This average should be segregated into three

classifications. These are:

- (1) Purchase decisions hedge or price or vendor minimum order requirements.
- (2) Safety stock decisions to minimize risk of stock-out.
- (3) Excess inventories.

BILL OF MATERIALS
STRUCTURE AND
MAINTENANCE

The system must be able to:

1. Maintain structured bills of material for multiple effectivities of SRBs, major assemblies and components.
2. Interpret design engineering bills into process engineering's manufacturing bills of material.
3. Freeze baseline planning bills of material to be used as standard costing and budgeting benchmarks.
4. Link bill of material components to drawing assembly location. This will be a cross-reference to a specific item depicted on an engineering drawing. This will be used to facilitate configuration management, and may also be used to manage SRB flow weight and balance for hybrid and multiple effectivity flights (i.e., left/right SRB compatibility control).
5. Identify alternative components which could be used as substitutes. For example, a previous effectivity could be used in some cases. These substitution decisions would require manual action after a determination of flightworthiness.
6. Identify component "where used" lists. This may

facilitate materials expediting where component "cannibalization" is an alternative to solve a priority problem. This will also facilitate disposition decisions which require identification of potential uses of an item, or item group as well as facilities component standardization programs.

7. Maintain a forecasted attrition bill of materials for refurbishment. This will identify probabilities of replacing each item in the bills of material for major assemblies. These probabilities will be determined by a failure rate/disposition analysis function for refurbishment. This attrition bill is necessary to plan materials requirements for refurbishment.

8. Coordinate engineering changes. Engineering changes are to upgrade flightworthiness, to reduce weight, or to reduce cost of SRBs. These engineering changes will be grouped by effectiveness of SRB. They require the following activities to be performed:

- (a) Paperwork development milestone control and expediting capability.
- (b) Work authorization document and routing updates (if necessary).
- (c) Engineering bill conversion to manufacturing bill requirements.
- (d) Work authorization document routing required to upgrade component effectiveness from the previous effectiveness.
- (e) Analysis of engineering change impact on:
 - (1) Inventory usability.
 - (2) Work-in-process.

- (3) SRB flightworthiness.
- (4) SRB weight control.
- (5) SRB cost buildup.
- (6) Production resource capacity.

9. Produce bill of materials maintenance reports such

as:

- (a) Single level bills of material.
- (b) Multilevel bills of material.
 - (1) Indented by bill structure.
 - (2) Summarized by raw material requirements only.
- (c) Single level where used lists.
- (d) Multiple level where used lists.
- (e) Effectivity comparisons with delta lists. This will identify engineering changes made in the progression of effectivities.
- (f) Refurbishment forecasted attrition bill analysis reports. This would include:
 - (1) Comparison of actual component usage to forecasted usage.
 - (2) Changes in attrition forecasts from one effectivity to the next.
- (g) Engineering change milestone performance and expediting reports.
- (h) Engineering approval cycle requirements.
- (i) Engineering change status.
- (j) Comparison of engineering bills to manufacturing bills.

- (k) Standard cost comparisons between effectivities and of effectivities against frozen budget benchmark bills.
- (l) Comparison of "as built" configurations to the planned effectivity bills. This comparison would report details of all deviations and identify engineering changes required to upgrade to the "as designed" configuration effectivity. The type of engineering change would be identified to allow determination of its necessity for inclusion. These types would include:
 - (1) Required for flightworthiness.
 - (2) Optional for flightworthiness.
 - (3) Weight control change.
 - (4) Cost control change.

10. Simplify engineering transactions control, data entry and information coordination. This will require:

- (a) Automation of bill of material maintenance.
- (b) On-line data manipulation.
- (c) On-line engineering change impact reports.

ROUTING STRUCTURE AND MAINTENANCE

The system must be able to:

1. Summarize work authorization document information into routing operations. For example, rather than explicit directions of a step-by-step approach to installing a Moog actuator, the routing operation would cross-reference the WAD, drawings,

labor certification, tools and describe the operation as "install Moog actuator per WAD number B _ _ _ _ ."

2. Link detailed resource requirements to routing operations. These resources include:

- (a) Work center time duration needed.
- (b) Labor standard hours by labor certification.
- (c) Tools required.
- (d) Ground support equipment required.
- (e) Subcontractor support required.

3. Block multiple work centers or a facility while hazardous operations are being performed.

4. Maintain best estimated routings for refurbishment capacity planning and resource loading.

5. Release modularized refurbishment routings to the shop floor. These modularized bills would be inactive until mod-uals required are selected. At that time capacity planning would substitute the activated modularized routing for the best estimated routing for refurbishment.

6. Maintain routings for engineering changes. These routings would identify upgrade operations to accomplish effectivity improvements of an item. These routings may be appended to another routing so that effectivity improvements can be included in an assembly shop order.

7. Facilitate temporary routings for either one-time operations such as rework, or future routing operations improvements. These would include the following current work

authorization documents:

- (a) TPS.
- (b) PR.
- (c) DR.

8. Allow parallel operations on the same routing. This would facilitate schedule manipulation and performance tracking.

9. Control routing changes by bill of materials effectiveness.

10. Identify "where used" links of resources to routings; i.e., traceability of where each resource might be employed.

These resources are:

- (a) Work centers.
- (b) Labor certifications.
- (c) GSE.
- (d) Tools.
- (e) Subcontractors.

11. Produce routing maintenance reports such as:

- (a) Routing network.
- (b) Resource requirements by operation.
- (c) Routing change status.
- (d) Comparison of refurbishments best estimate bill to actual modularized activity bills.
- (e) Comparison of actual routing and shop floor data to standard routing data. This would include:
 - (1) Standard cost variance analysis.
 - (2) Labor performance.

- (3) Work center utilization.
- (4) GSE, tools and subcontractor productivity.

PURCHASING

The system must be able to:

1. Translate materials requirements planning purchase requisition recommendations into purchase orders requests. The requisition recommendations will project the most effective manufacturing plan requirements. Purchasing decisions should include:

- (a) Balancing inventory carrying costs (including design obsolescence) with purchase economies. For example, determine purchase economic order quantities.
- (b) Vendor sourcing.
- (c) Purchase receipt scheduling, expediting and deexpediting.
- (d) Blanket order coverage.
- (e) Vendor performance analysis. This would include:
 - (1) Delivery performance.
 - (2) Quality performance.
 - (3) Milestone performance.
 - (4) Information support performance.
- (f) Vendor negotiations on:
 - (1) Price.
 - (2) Quality.
 - (3) Service.

- (g) Technical support requirements.
- 2. Track purchase order receiving schedule information by item and estimated due date. This information is required for a production control system to perform materials requirements planning.
- 3. Identify purchase order exceptions. These would include:
 - (a) Requirements not on released purchase orders which are within the normal vendor lead time.
 - (b) Planned purchase receipts which will be too late to satisfy the item requirement date. This will require purchase order or order line item expediting.
 - (c) Deexpediting opportunities.
- 4. Monitor refurbishment orders of components returned to vendors. This will require item serial number control and configuration control.
- 5. Place "full unit" purchase orders to satisfy requirements of less than one. Partial item requirements may be generated by the explosion of the refurbishment forecasted attrition bill of materials.

GENERAL SYSTEM
REQUIREMENTS

The system must be able to:

- 1. Flag "abnormalities" and other exceptions, such as "as built" versus "as designed" deltas.
- 2. Purge working files periodically (weekly or monthly)

in order to maintain such files at a manageable size. This would include files such as labor, by certification, applied to a refurbishment operation.

3. Create transactions and pass them to other systems and subsystems such as modified ACMS and a revised version of ADMS.

4. Reflect item status or schedule status on CRTs or hard copy, such as refurbishment/subassembly routings, generation breakdown, etc.

5. Generate notices of schedule slippage and overapplied resources as a form of exception reporting, such as inspection activities in stocking not performed.

6. Generate reports at various levels of detail, from direct line management up to executive management of USBI and program management of NASA.

7. Utilize state-of-the-art Manufacturing Resource Planning as the central management mechanism.

8. Provide an MRP-type system which has both "net change" and "regenerative" logic.

9. Operate on a minimum of "safety stock" but still provide some safety stock consideration due to the following conditions:

- (a) Critical nature of certain items needed to ensure flight/mission integrity.
- (b) Long vendor lead time.
- (c) Recovery loss rate probability

of an entire SRB, a major component (aft skirt) or an LRU.

- (d) Failure rate of components (estimated).
- (e) Unknown degree of variability in all of the above.

10. Master schedule at two levels:

- (a) Major subassembly.
- (b) Discrete launch (2 SRBs per launch).

11. Provide for a bill of material based upon a statistical forecast of component attrition rates.

12. Provide for capacity loading based upon multiple but predetermined routings for the same component or subassembly dependent upon actual condition of the retrieved SRB.

13. Provide direct link from shop floor scheduling to daily operational tracking and performance monitoring in order to monitor refurbishment, subassembly, stacking, mating, recovery, and disassembly and cleaning.

14. Provide for daily updating of material and resource needs based upon operational reporting as well as existing shop floor schedule.

15. Plan across a material lead time horizon of up to three years.

16. Plan across a refurbishment/subassembly, and stacking cycle time horizon of up to two years.

17. Provide for capacity planning and shop floor scheduling across time frames of several (six) months by shift and day.

18. Provide for the utilization of "scarce" human resources in GSE maintenance roles. However, consideration should be given to the creation of a separate organization for such GSE maintenance work, due to the following:

- (a) Scheduling priority difficulties between refurbishment and GSE maintenance.
- (b) Learning curve effect of workers assigned to in-flight hardware related work alternating with GSE maintenance work.
- (c) Continuity of work flow on GSE.

19. Provide for numerous (several hundred) engineering change notices each month, while recognizing that the volume and magnitude of such changes should decrease as designs are stabilized and standardized.

20. Provide for subassembly interdependence across major assemblies.

21. Provide for shop floor scheduling for a minimum of four weeks.

22. Verify that inventory, tool, test equipment and fixtures, manpower, facility, and critical GSE are available prior to the release of orders to the shop floor. If one or more of the above items are found to be unavailable, exception reports will be generated indicating the specific nature of the shortage.

23. Provide the ability to track inventory in several permanent and temporary locations by part number, serial number, and other status codes required to differentiate level of flight-worthiness, degree of refurbishment, or effectivity.

24. Provide for shift operational tracking of actual progress to "standard", for performance reporting, monitoring and corrective action.

25. Provide a system compatible with the following objectives of "good systems design".

- (a) Provide information to assist USBI to make timely and accurate decisions.
- (b) "Dovetail" other systems to minimize duplication, contradiction, and suboptimization.
- (c) Provide for the best use of computer technology; e.g., processing data with recognition of changing conditions. At the same time, recognize that an overly automated system leads to a "hands-off" attitude which is extremely detrimental to any organization.
- (d) Reduce costs, through improved management control of operations with greater flexibility to detect and respond to significant changes.
- (e) Reduce paperwork to a minimum. This will provide an environment of management by exception, while retaining on computer files data necessary for NASA's retrieval requirements; i.e., data pack information.

IV - BUSINESS SYSTEM DESCRIPTION

INTRODUCTION

This section provides a detailed description of the business system which has been developed to meet the SRB production control needs. These business system requirements were defined in the previous section.

In this section a business system overview is presented, in which each of the mainstream systems modules (or subsystems) are defined in terms of major functions and features, key inputs, key outputs and key data file requirements. The other subsystems are also briefly described in this discussion.

Following the business system overview, the mainstream subsystems are discussed in greater detail, including a subsystem flowchart, a description of the subsystem and a definition of key inputs and outputs.

This is followed by a description of the information flows, as well as a description of work control station activities dictated by the automated production control system.

BUSINESS SYSTEM OVERVIEW

(a) Introduction

The purpose of this narrative and the accompanying flowchart is to describe the overall business systems flow, and the interfaces between key systems modules. The business systems requirements,

developed in the previous section, are the basis of this business systems overview. The overriding objectives used to develop this overview are to apply field-proven manufacturing management and production control systems technologies to the SRB production control operations environment, and to integrate these technologies with both NASA and USBI top management control needs.

The mainstream system modules in the production control system are:

1. Master scheduling/resource planning.
2. Materials requirements planning.
3. Capacity requirements planning.
4. Shop floor management.
5. Operations control.
6. Performance analysis.

In addition, the following modules are needed to support the mainstream system modules:

1. Launch schedule.
2. Refurbishment scheduling.
3. Resource planning bill maintenance.
4. Resource availability plan maintenance.
5. Bill of material maintenance.
6. Inventory control.
7. Purchasing.
8. Preventive maintenance.
9. Routing and work authorization document maintenance.

10. Configuration management.
11. Labor control.

Finally, there are fourteen business systems requirements which are embedded in the systems modules. These requirements are:

1. Effectivity control.
2. Part life cycle management.
3. Part attrition planning.
4. Shared GSE integration.
5. Subcontractor integration.
6. Hazardous operations control.
7. Quality control and inspection.
8. Sign-off control.
9. Engineering documentation control.
10. SRB effectivity hybrid weight and balance control.
11. Spares risk management.
12. Operations budgeting.
13. Performance monitoring systems.
14. Launch mission compliance risk analysis.

Each system module is described in the narrative sections following the "SRB/Production Control Systems Overview" flowchart (Figure IV-1). Each section contains the following subsections:

1. Summary Narrative.
2. Major Functions and Features (mainstream only).

3. Key Inputs (mainstream only).
4. Key Outputs (mainstream only).
5. Key Data File Requirements (mainstream only).

(b) Narrative and
Flowchart

The mainstream systems modules, which are outlined in Figure IV-1, perform production planning, and production operations management and control. Production planning is designed to plan in four time horizons. These are a facilities and resource planning horizon, a materials planning horizon, a resource loading horizon, and a resource assignment horizon. The facilities and resource planning horizon is for five or more years and is accomplished by master scheduling. The materials planning horizon is for two to three years and is accomplished by materials requirements planning. The resource loading horizon is for three to six months and is accomplished by capacity requirements planning. The resource assignment horizon is for two to four weeks and is accomplished by shop floor management (dispatching).

Production operations management and control is designed to issue needed information to operations, to expedite or deexpedite work-in-process based on launch or aisle transfer schedule priorities, to track progress of work and to monitor resource utilization and work productivity. Issuing needed information to operations is a daily activity and is accomplished by shop floor management (job packet issuance). Expediting and deexpediting work-in-process is a continuous activity and is accomplished by

operations control (work center queuing control). Tracking work progress is a continuous activity and is accomplished by operations control (work status data collection). Monitoring resource utilization and work productivity is a periodic (weekly and monthly) activity and is accomplished by performance analysis.

The support systems modules create and maintain data necessary for the mainstream production planning and control system. The mainstream system modules and the associated support systems modules are shown in the table on the following page.

Table IV-1

Mainstream and Support System
Modules Relationships

<u>Mainstream Modules</u>	<u>Associated Support System Modules</u>
1. Master Scheduling	(a) Launch Scheduling (b) Refurbishment Scheduling
2. Resource Planning	(a) Resource Planning Bill Maintenance (b) Resource Availability Plan Maintenance
3. Materials Requirements Planning	(a) Bill of Material Maintenance (b) Inventory Control (c) Purchasing
4. Capacity Requirements Planning	(a) Routing and Work Authorization Document Maintenance (b) Configuration Management (c) Preventive Maintenance Scheduling
5. Shop Floor Management Operations Control	(a) Inventory Control (b) Preventive Maintenance Scheduling (c) Routing and Work Authorization Document Maintenance (d) Configuration Management
6. Performance Analysis	(a) Labor Control (b) Configuration Management

In the remainder of this subsection, each of the system modules, both mainstream and support system, are described. Following that, each system module is detailed in terms of objectives and key inputs and outputs, using a flowchart to illustrate the module's operation.

MAINSTREAM MODULES(a) Master Scheduling/
Resource Planning

1. Summary Narrative. Master Scheduling/Resource Planning is designed to generate a "doable" production plan: This is accomplished by interpreting the launch schedule into an aisle transfer schedule, by assigning a new or refurbished major assembly to the aisle transfer, by ensuring that resources will be available to meet launch and aisle transfer schedules, and by ensuring that operations budgets commit the funds necessary to achieve resource availability plans.

The management processes required to generate the master schedule require the integration of facilities and resource planning as well as program operations budgeting.

2. Major Functions.

- (a) Generate aisle transfer schedule requirements.
- (b) Generate refurbishment schedule capabilities.
- (c) Assign new or refurbished major assemblies to aisle transfer requirements.
- (d) Extrapolate resource requirements from launch schedules and aisle transfer schedules.
- (e) Balance resource availability plans to resource requirements.
- (f) Cost resource availability plans.
- (g) Determine schedule milestones and resource planning assumptions.
- (h) Develop program operations budgets.

3. Key Inputs.
 - (a) Launch schedule.
4. Key Outputs.
 - (a) Master schedules (launch and aisle transfer).
 - (b) Rebalanced resource availability plans.
 - (c) Validated program operations budgets.
5. Key Data File Requirements.
 - (a) Aisle transfer elements and cycle times to launch.
 - (b) Recovery, cleaning, disassembly, and refurbishment cycle times to aisle transfer.
 - (c) Resource planning bills of material for launches, and new or refurbished aisle transfer elements.
 - (d) Resource availability plans.
 - (e) Resource costing parameters.
 - (f) Schedule and resource plan milestones and assumptions.
 - (g) Inventory control data for major assemblies.

(b) Material Requirements Planning

1. Summary Narrative. Materials Requirements Planning (MRP) is designed to develop time-phased materials requisitions for purchasing and to develop time-phased production requisitions for capacity planning. These time-phased requisitions coordinate the planned receipts to planned disbursements. The objective of

MRP is to minimize inventory by controlling the planned time between receipts and disbursements of materials and assemblies. Risk of a disbursement need occurring before material is received is countered by use of safety stock and safety margin cycle times. Both can be statistically calculated and controlled to plan materials with a definable stock-out risk level.

The SRB production control environment requires that MRP accommodate four unique planning requirements. These are refurbishment materials planning, alternative effectivity component netting, alternative component flightworthiness status netting, and planning configuration management. Each of these requirements is reviewed in the paragraphs which follow.

Refurbishment materials planning requires that materials and production components to be requisitioned be based on forecasted attrition rates, on projected spent assembly "as built" life and effectivity analysis, or on refurbishment test results analysis.

Alternative effectivity component netting is the system capability to search prior effectivities to determine which can be upgraded and assigned to a more recent component effectivity requirement. This activity necessitates the creation of a rework order to upgrade the component effectivities, and the scheduling of rework orders to receive the upgraded component when required. This alternative effectivity netting logic assumes that component effectivity upgrades will be done as needed, which will minimize inventory value added. There will be two alternative effectivity netting logic capabilities. These are FIFO and LIFO. FIFO is

"first in first out" which means that the oldest upgradeable effectivity would be used first, thereby adding more value to the SRBs, but also keeping average inventory at a more current effectivity level. LIFO is "last in first out" which means that the latest upgradeable effectivity would be used first, resulting in the least value added to the SRBs, but also resulting in having an older average effectivity in inventory. FIFO would be most practical for a new series of upgradeable effectivities; but LIFO would be most appropriate for a component that would not be upgradeable sometime in the near future.

Alternative component flightworthiness status netting is the system capability to search component status and assign components on a status priority basis. These alternative statuses could include flightready, rework required, or test and disposition required. If rework required status is assigned, then a rework order would be created to receive the flightready component when required. If test and disposition is assigned then a test and disposition order would be created with sufficient lead time to react to an alternative source if the disposition is "nonrepairable".

Planning configuration management is the system capability to isolate the planned "as designed" configuration for an effectivity, to plan materials based on that "as designed" configuration, and to adjust materials plans if changes are made to the planned "as designed" configuration.

2. Major Functions.

- (a) Explode master schedules to gross materials requirements.
- (b) Create launch "as designed" configuration.
- (c) Net materials requirements to inventory (component) planned availability.
- (d) Reserve inventory on-hand or planned receipts.
- (e) Generate materials requisitions and production requisitions.
- (f) Adjust or expedite materials requisition schedules and production requisition schedules per master schedule changes.
- (g) Reserve inventory on-hand or planned receipts.
- (h) Group purchase requisitions by component and component commodity class.
- (i) Group production requisitions by component and like production process type.

3. Key Inputs.

- (a) Schedule adjustments.

4. Key Outputs.

- (a) Launch planned configuration.
- (b) Material requisitions.
- (c) Production requisitions.
- (d) Expedite/deexpedite reports.

5. Key Data File Requirements.

- (a) Master schedule.

- (b) Bill of materials.
- (c) Forecasted attrition bill of materials.
- (d) Inventory (by effectivity and status).
- (e) Purchase orders.
- (f) Production requisition schedules.
- (g) Shop order schedules.

(c) Capacity Requirements Planning

1. Summary Narrative. Capacity Requirements Planning (CRP) is designed to schedule work through production work centers and to load available resources within resource capacity constraints. To accomplish these two activities, first the production requisition schedule must be translated into work operations schedules. This is done by exploding production requisitions through routing operations to define the sequence and duration of work operations at each work center. This defines the job schedule by work center. The sum of all operations requiring a specific work center during a time period defines the work load. The work load is then compared to the available capacity (both theoretical and practical) and adjustments are made, if needed. Adjustments could be made by changes in schedule, by the use of alternate work centers, or by additions of capacity.

Other resource loading activities would be accomplished by using the same logic as work center loading. These other resource loadings would include labor by skill certification,

tools, GSE and subcontractors.

Preventive maintenance schedules would also be planned through the same system.

Production requisition would include planned production requisitions, firm planned shop orders and released shop orders.

The SRB production control environment requires that CRP accommodate, at a minimum, five unique planning requirements. These are labor and work center capacity loading; refurbishment resource requirements planning; preventive maintenance resource requirements; planning routing configuration tracking; and tools, supplies, GSE and subcontractor requirements projections. These requirements are described below.

Labor and work center capacity loading requires that routing operations data specify both work center duration per operation and standard labor time per operation, by certification level.

Refurbishment resource requirements planning requires a specialized three-stage routing track with a specific refurbishment order. The three-stage routings are the forecasted attrition planning routing, the hybrid attrition and anticipated component replacement routing, and the refurbishment post-test routing.

Preventive maintenance (PM) resource requirements planning requires that PM orders be set up similarly to shop orders. That is, a PM shop order would have a PM activity number in the part master file and a PM routing in the work routing file. This will facilitate scheduling PM through the

same facilities while ensuring resource availability.

Routing configuration tracking requires that the production requisition routing be assigned to a particular shop order. This is needed to track actual work performed on a routing and decisions adjusting a routing. This routing will be used to monitor installation process exceptions for buy-off review consideration.

Tool, supplies, GSE and subcontractor requirements projections require that routing operations data specify the resources and time required per operation. This information and the operation schedule information will be the basis of integration requirements communications.

2. Major Functions.

- (a) Explode production requisitions, through shop routings.
- (b) Explode from planned shop orders and released orders through their "as planned" work routing configuration for work remaining.
- (c) Explode preventive maintenance (PM) shop orders through PM routings.
- (d) Sum work center loads by work center.
- (e) Sum labor loads by skill certification.
- (f) Compare resource availabilities to capacities.
- (g) Adjust schedule, routing or capacity plans, if necessary.
- (h) Project tools, supplies, GSE and subcontractor requirements.

3. Key Inputs.

- (a) Schedule adjustments.
- (b) Routing adjustments.
- (c) Capacity adjustments.

4. Key Outputs.

- (a) Revised production and PM schedules.
- (b) Work center time-phased capacity load reports.
- (c) Manpower time-phased capacity load reports.
- (d) Tool, supplies, GSE and sub-contractor requirements schedules.

5. Key Data File Requirements.

- (a) Production requisition schedules.
- (b) Shop order schedules.
- (c) PM schedules.
- (d) Routings with resource requirements.
- (e) Shop order work remaining "as planned" routing.

(d) Shop Floor Management

1. Summary Narrative. The shop floor management subsystem is designed to schedule work to, and on, the shop floor. This includes three major activities: work dispatching; work documents assembly and release; and work-in-process scheduling, expediting and deexpediting.

Work dispatching activities are the scheduling of work

on the shop floor through work centers and the preverification that needed resources will be available to accomplish the scheduled work. This preverification of resources will include checks of inventory availability, of worker assignments, of GSE commitments and of subcontractor commitments. Most elements of GSE and subcontractor preverification will be manual.

Work document assembly and release is the assembly of necessary documents for production and dissemination of these documents to the appropriate function. These documents would include inventory picking lists and requisitions, engineering drawings and routings, work authorization documents, labor certification requisitions and time cards, tools and supply requisitions and logging cards, GSE requisitions and logging cards, and subcontractor requisitions and time cards.

Work-in-process schedule expediting and deexpediting is the priority management of work. These priorities can be influenced by schedule changes, scarcity of resources, lateness of work performed, and exception changes in routing work remaining.

2. Major Functions.

- (a) Automatic inclusion of work due to start within a two- to four-week dispatch schedule horizon.
- (b) Dispatcher priority review of PM, inventory replenishment, and pegged requirements shop orders.
- (c) Prerelease verification of resource availability.
- (d) Expediting of scarce resources.

- (e) Preparation of work documents.
- (f) Dissemination of work documents.
- (g) Expediting and deexpediting of work-in-process.

3. Key Inputs.

- (a) Shop orders due to start within the next two to four weeks.
- (b) Dispatcher priority changes.
- (c) Dispatcher-forced release of orders requiring scarce resources.
- (d) Integration resource commitment (manual process from authorized party able to commit shared resources).

4. Key Outputs.

- (a) Shop floor daily dispatch schedules by operation.
- (b) Work documents and support document cross-reference lists.
- (c) Shop floor priority reports.

5. Key Data File Requirements.

- (a) Production requisition schedules.
- (b) Shop order schedules.
- (c) PM schedules.
- (d) Launch "as designed" configuration.
- (e) Shop order "as planned" routings.
- (f) Inventory.

(e) Operations
Control

1. Summary Narrative. Operations control is designed to provide the information needed to manage work-in-process (WIP). This information will track the status of each shop order in WIP by work center, will identify any exceptions to shop floor dispatch schedules or planned resource requirements, and will provide the means to expedite, deexpedite or reprioritize shop orders in WIP.

Shop order status is tracked by collecting data for resource consumption and work progress, by operation, on the shop order routing. Resource consumption tracks the logged time against a work center, the actual labor time, by labor skill certification, the supplies issued, the logged time against tools, GSE or subcontractors WAD deviations; and the materials, components and subassemblies issued. Shop order status is determined by comparing actual resource consumption to the planned consumption. For example, work remaining is determined by routing operations not logged out as completed. Another example might be the determination of schedule priorities of shop orders at a work center by the time required to complete each shop order on time, relative to the time available.

Exceptions are identified by comparing current shop order status to the shop floor plan. These exceptions would include the following:

- (a) Late operations.

- (b) Time required to complete a shop order on schedule exceeding the time available.
- (c) Operation time at a work center exceeding the planned time.
- (d) Excess labor applied to an operation.
- (e) Excess tools, GSE, or subcontractor time logged against an operation.
- (f) Nondelivery or nonperformance of tools, GSE, or subcontractors.
- (g) Unusually high or low productivity of a worker on an operation.
- (h) Excessive, insufficient or substitute materials or supplies applied to a shop order.

The vehicles for expediting, deexpediting, or reprioritizing shop orders are the shop order routing and operation priority code techniques, the monitoring of shop floor conformance to the priority signals, the perpetual status and exception signaling to dispatchers and work control stations, and the capability to signal to the shop floor a need for immediate action on a particular operation or to signal the desired action to be taken. For example:

- (a) Expediting an operation is achieved by raising its priority.
- (b) Deexpediting is achieved by lowering priorities.
- (c) Stopping further work on a shop order is achieved by changing the priority to a hold status.
- (d) Alternative work center, labor skill certification, tools, or

GSE are signaled by a routing operator substitution transaction.

- (e) Variations in operations sequences are signaled by routing operation sequence change transactions.
- (f) Addition of operations, such as TPSs, PRs and DRs are achieved by routing operations addition transactions.

The SRB production control environment requires that Operations Control accommodate three unique shop floor management requirements. These are refurbishment operations control, configuration data accumulation, and distributed shop floor work control stations for data collection and dissemination. Each of these is discussed on the following pages.

Refurbishment operations control requires that the refurbishment order bills of material and routings be updated based on test results. This will be achieved by test results being translated into a component kit "accept or reject" transaction. These transactions will be triggered from a test results matrix which will list all tests to be completed and all component kits which could be replaced. The rejected components would be entered into the SRB production control system which would add the components and parts needed to replace the rejected components and would add the routing operations to dismantle the old parts and components and install the replacement parts and components. Also, disposition tickets would be generated to track the status of dismantled parts and components. The accepted components would

trigger an update of the refurbishment "as built" configuration data by repegging the previous "as built" component configuration to the new "as built" next higher assembly configuration.

Configuration data accumulation requires that actual component installation be tracked by component serial number and actual shop floor routing sequence and that resource consumption and inspection authority be tracked by operation. Component installation can be assigned to a location on the drawing where duplicate components are installed with the same routing. This will simplify life cycle history tracking where a component is in the primary, secondary, or tertiary position of redundant operating systems.

It will also be necessary for weight and balance calculations if a hybrid SRB assembly uses the same function components of different weights. The unique "as built" configuration data control for refurbishment was described in the preceding paragraph.

Distributed shop floor work control stations are required to disseminate data to, and collect data from, the work centers. Further, the need for volumes of hard copy drawings and work instructions makes it necessary to set up multiple work control stations on the shop floor which are located near the work centers.

2. Major Functions.

- (a) Disseminate job packet information by operation or at the beginning of each shift.

- (b) Gather shop order resource consumption data by operation or at shift end.
- (c) Enter resource consumption data into the automated shop floor management system.
- (d) Communicate shop order priorities to shop floor supervisory personnel.
- (e) Gather shop order exception information from shop floor supervisory personnel.
- (f) Enter exception data into the automated shop floor management system.
- (g) Alert dispatching to exceptions.

3. Key Inputs.

- (a) Work centers logged onto an operation.
- (b) Work centers logged off of an operation.
- (c) Worker with a specific labor skill certification clocked on to an operation.
- (d) Worker clocked off of an operation.
- (e) GSE logged out to an operation.
- (f) GSE logged in from an operation.
- (g) Subcontractors logged on to an operation.

- (h) Subcontractors logged off of an operation.
- (i) Priority charges.
- (j) Supplies disbursed to an operation.*
- (k) Materials per picking list or special requisition released to a routing.*
- (l) Tools logged out to an operation.*
- (m) Tools logged in from an operation.*

4. Key Outputs.

- (a) Shop order status reports.
- (b) Exception alert reports.
- (c) Priority compliance reports.

5. Key Data File Requirements.

- (a) Shop order dispatch schedules.
- (b) Shop order routings.
- (c) Shop order bills of material.

(f) Performance Analysis

1. Summary Narrative. Performance analysis is designed to measure the performance of production planning, scheduling

* These inputs will be made through subsystems managing supplies, materials and tools.

and operations. The primary objective is to compare actual performance and "as built" configurations to each level of planning. These levels include:

- (a) Daily shop floor dispatch schedules.
- (b) "As planned" routings and resource plans by operation.
- (c) "As designed" bill of materials configuration.
- (d) Capacity requirements planned resource loads.
- (e) Materials requirements planning schedules of material needs.
- (f) Master scheduling resource plans.
- (g) Master scheduling operations budgets and assumption milestones.

Performance analysis will be reported as a shop order routing is completed and then summarized on a periodic basis. Period summary information will be maintained to track performance from one period to the next.

Shop order performance analysis will report labor productivity, resource utilization and materials usage against standards. Cost variances would also be reported. This information would be duplicated on low-cost, low-access storage media, such as microfiche, for configuration data history accumulation. This would be done for each level of assembly, then repeated through off-line data capture, for all components and lower levels of each higher assembly up to the SRB flight set. These performance data will remain available on-line up to the "buy-off

procedure", and will assist "buy-off" inspectors in identifying any unusual performance that should be examined in more detail. For example, the detailed BOS or OMI may be pulled on an exception basis to analyze the detail procedures. Any deviations from detailed WADs would have been recorded in routing operation memo notes and would also be available on-line.

Period performance analysis would be used to report resource productivity, cost performance and planning assumption tracking. This information would be transmitted to operations budget tracking and the performance monitoring subsystems. These data would include:

- (a) Actual cost data.
- (b) Actual output data (launches).
- (c) Milestones and performance assumptions, such as:
 - (1) Actual labor utilization (percent time on standard).
 - (2) Actual labor productivity (percent actual time versus standard).
 - (3) Actual overhead to labor ratio.
 - (4) Actual work center utilization.
 - (5) Actual versus standard value added per launch.
 - (6) Actual versus planned value added to inventory.
 - (7) Actual inventory turns.
 - (8) Launch schedule compliance.

- (9) Aisle transfer schedule compliance.
- (10) Dispatch schedule shop floor compliance.
- (11) Actual versus standard purchase variance.
- (12) Actual excess inventory due to hedge or minimum order buying.
- (13) Actual materials shortage rate.
- (14) Actual labor shortage rate (by skill certification).
- (15) Actual work stoppage cost (special code shop order value added) for material, labor, tools, GSE or subcontractor scarcity.
- (16) Actual preventive maintenance value added.
- (17) Actual SRB recovery loss rate.
- (18) Actual component attrition rates.
- (19) Actual attrition disposition rate to rework.
- (20) Actual attrition disposition rate to vendor rework.
- (21) Actual attrition disposition rate to parts tear-down and recovery.
- (22) Actual attrition disposition rate to disposal.
- (23) Actual design attrition cost.
- (24) Actual learning curve savings from materials cost

reduction programs (design engineering changes).

- (25) Actual learning curve savings from methods or process cost reduction programs (production process engineering changes).

2. Major Functions.

- (a) Report shop order performance upon completion of each shop order.
- (b) Off-load detail operations "as built" data to off-line storage (or system; e.g., ACMS).
- (c) Report period summary performance, including:
 - (1) Worker utilization (time on standard).
 - (2) Worker productivity (time on actual versus standard).
 - (3) Work center utilization.
- (d) Summarize period data for operations budget tracking and performance monitoring.
- (e) Provide "data pack" information for "buy-off" analysis (may not be in form of sufficient detail for actual "buy-off").

3. Key Inputs.

- (a) Shop order completion.
- (b) Period cut-off dates.

4. Key Outputs.

- (a) Shop order performance reports.
- (b) SRB, major assembly, subassembly and component "as built" configuration detail data for storage (e.g., microfiche, ACMS, etc.)

- (c) Period performance reports.
- (d) Operations budgeting and performance monitoring subsystem data assimilation (initially in physical units).

5. Key Data Files Required.

- (a) "As built" configuration data.
- (b) Worker master file.
- (c) Labor skill certification master file.
- (d) Labor department master file.
- (e) Work center master file.
- (f) Work center group master file.
- (g) Inventory part master file.
- (h) Supplies and tools part master files.
- (i) GSE master file.
- (j) Subcontractor master file.
- (k) Original shop order schedule dates for:
 - (1) Launches.
 - (2) Aisle transfer.
 - (3) Daily dispatch order completion dates.
- (l) Operations budgeting planning assumptions.
- (m) Inventory data.
- (n) Hedge buy inventory data.
- (o) Materials shorted temporary work file.
- (p) Labor skill certifications shorted temporary work file.

- (q) Special shop orders for work
stoppage.
- (r) Preventive maintenance shop
orders.

ANCILLARY SUBSYSTEMS

(a) Launch Scheduling

Summary Narrative. Launch scheduling is the primary input to the SRB automated production control (APC) system. It is the planned launch date for each flight.

The objectives of the APC system are to:

1. Determine if the launch schedule is "doable".
2. Define the resources needed to achieve the launch schedule.
3. Manage the available resources to achieve the launch schedule.

(b) Refurbishment Scheduling

Summary Narrative. Refurbishment scheduling is designed to provide a scheduling basis for refurbishment. The subsystem will use standard lead times for scheduling recovery, cleaning and disassembly, and refurbishment to establish major assembly earliest available date for aisle transfer. Each refurbishable major assembly will have its own refurbishment cycle time.

Refurbishment schedules will be adjusted based on aisle transfer requirements for each launch.

(c) Resource Planning
Bill Maintenance.

Summary Narrative. Resource planning bill maintenance is designed to maintain gross resource requirements per launch, per recovery, cleaning and disassembly of a spent SRB, or per new or refurbished major assembly aisle transfer.

These resources would be time phased over the production cycle times. This will allow the projection of resources required period by period over the planning horizon. Resource projections by period would sum resources needed for every production activity scheduled to be in-process at that time.

The resources developed in this planning bill will include:

- (a) Critical materials.
- (b) Other materials by commodity class.
- (c) Critical work centers.
- (d) Like work center groups (not critical).
- (e) Labor skill certifications.
- (f) Supplies.
- (g) Critical tools.
- (h) Other tools.
- (i) Critical GSE.
- (j) Other GSE.
- (k) Critical subcontractor activities.

- (l) Other subcontractor activities.
- (m) Overhead items directly related to production.
- (n) Other resources directly related to production.

(d) Resource
Availability
Plan Maintenance

Summary Narrative. Resource availability plan maintenance is designed to record the time-phased resource plans needed to achieve the launch schedule. These plans would include all resources that would be costed out to produce an operations budget (or any resource that would be included in the POPs).

(e) Bill of Material
Maintenance

Summary Narrative. Bill of Material (BOM) maintenance is designed to provide the information needed to schedule materials through production to launch. This scheduling coordinates materials receipts, rework, subassembly, assembly, stacking, etc., with specific materials, or production outputs planned to be available at the same time as they are needed for the next production activity. Thus, the subsystem's purpose is to provide the information needed to plan a fully coordinated materials flow from materials receipt, through production and to launch. The BOM is structured to flow materials through work-in-process with no idle inventory or wait time between shop order completions and the next requirement. Contingencies to counter risk of unusual events are not provided for in the BOM, but would be

in inventory policy, and shop floor expediting capabilities.

The BOM is structured to identify the components required for the manufacture or assembly of each level of production and to sum that production up level by level to the final SRB flight set. This results in a "tree-structured" network of materials through each level of production, up to the final SRB flight set.

This "tree-structure" may differ between design engineering and manufacturing. For proper scheduling and work-in-process inventory management, the engineering BOM must be converted to reflect the flow of the manufacturing process. This is accomplished by inserting "pseudo levels" into the BOM, by inserting manufacturing defined semicomplete assembly level components, or by flagging components or BOM levels as engineering only.

The SRB production control systems environment requires that BOM maintenance accommodate five unique planning requirements. These are configuration control, launch effectivity control, refurbishment attrition materials planning, component locator cross-referencing to the drawing, and engineering change status and authorization management. These are discussed below.

Configuration control requires that the launch structured BOM (generation breakdown) track with the buildup of the flight set. The original BOM would be frozen as the "as designed" when work is initiated on the flight set. The "as built" configuration would be built up as work is completed, but the frozen "as

designed" will not be changed. Engineering changes to the original "as designed" BOM would be communicated to the frozen "as designed" shop order. Then manual inclusion or exclusion decisions can be made. When work is completed the data pack would include work done, "as designed" engineering changes incorporated and those not incorporated. Furthermore, the configuration "as built" versus "as designed" deltas would include the engineering change actions to bring the "as designed" to the current specifications.

Launch effectivity control requires that the production control system facilitate management of an evolving SRB flight set design. Engineering changes will be mostly directed at future launches or series of launches rather than having only one active design. The engineering changes for future SRBs will be categorized by need, and some changes will be optional. For example, some changes may be mandatory for improved flight-worthiness, but other changes may be optional for cost or weight reduction. These factors make it necessary to control engineering changes by launch effectivity and to identify changes by the date authorized. Therefore, the "as designed" will relate to specific launch, but engineering changes to that effectivity can be identified by authorization date.

Attrition materials planning requires that refurbishment bills of material incorporate the probabilities of replacing a component. These probabilities are represented in fractional requirements. For multiple refurbishments having the same

components, these fractional requirements are summed to project the next full component requirement. Orders would be initiated for the first fractional requirement which is not covered by a previous order. If an order is placed for a fractional requirement which is not used, then that order will cover following fractional requirements and succeeding orders would be rescheduled to a later period.

Attrition materials planning must also be cognizant of effectivity evolutions. Where a part changes effectivity too often, attrition logic would place too many orders. Therefore, attrition orders should be tempered by the expected component design evolution.

For example, if an order is placed to cover a 10% probability of requiring a component for two refurbishments and the component effectivity changes, a system would place an order to cover a 20% probability of needing the component. A manual decision should be made on that order. Other contingency factors would be considered in this decision, including:

1. The ability to rework attrition component.
2. The effectivity upgradability of the component.
3. The substitutability of other effectivity components.

Component locator cross-referencing to the drawing requires that each component depicted on the drawing cartoon be identified by a reference number. This component location on a drawing would

be included in the BOM to be used to assist life history management in identifying the function of a component which may be used in primary or redundant operations modules. This location could also be used to identify weight and balance factors (if needed).

Engineering change status and authorization management requires that planned engineering changes be included in the BOM, but that an engineering status code identify its anticipated effectivity. This is necessary so that all planned engineering changes be communicated to all functions which are dependent on this information. For example, purchasing must consider materials requirements two and three years into the future. Therefore, if a change is planned within that time, they need to know. It is also important that the change authorization process milestones be tracked. This is needed to ensure proper communications and on time final authorization.

(f) Inventory Control

Summary Narrative. Inventory control is designed to manage and control materials, subassembly work-in-process, and spent major assembly inventories. The management activities of inventory control are inventory transaction accounting, location control, in-transit control, planned receipts control, receiving and inspection, purchasing revalidation of receiving, planned disbursements (part reservation or allocation) control, cycle counting, audit trail transaction tracking, error correction, and performance measurement.

Inventory transaction accounting is recording the "ins" and "outs" (receipts and disbursements) of inventory. Receipts can be vendor receiving or production and rework completion. Disbursements are issues to shop orders, to vendor rework orders or to disposition orders. In addition, any inventory adjustments would be recorded.

Location control is the identification of the physical space in an inventory segregation area where the part resides. This could be a storage bin locator or a spot on the floor. This location control requires a "move" transaction for each time a part moves from one location to another location.

In-transit control is the identification of parts which are moving from one segregation area to another. This would use the inventory locator to identify the route of the in-transit move. For example a "move part XYZ from area A123 to A-B" would record an in-transit from location 123 of segregation area A to segregation area B. It should be noted that work-in-process moves would be routing operations, not inventory location moves.

Planned receipts control is the linking of estimated time of completion of shop orders and estimated arrival time of vendor shipments to the part or serial number. This allows the APC system to time phase planned receipts of parts so that future receipts can be allocated to specific shop orders.

Receiving and inspection are inventory activities which record receipts against purchase order receiving documents or shop order completion receiving documents. For purchase order receiving, the parts would be moved to an inspection activity for part disposition. This disposition could be flightworthy, rework required or return to vendor. For shop orders, inventory would be moved to a segregation storage area or to a component kit awaiting disbursement to another shop order.

Purchasing revalidations of receiving is designed to provide a cross check to receiving accuracy. This is done through the validation of vendor invoices to purchase receiving and inspection documents. Corrections (if any) may trigger inventory cycle counting or audit control to confirm the accuracy of the correction.

Planned disbursements (part reservation or allocation) control is the assignment of inventory on-hand, or of planned receipts, to a specific shop order. This may be a suggested assignment which would be manually approved. The manual approval or an alternative assignment is made for serialized parts.

Cycle counting is the process of physical inventory count control. This is necessary to:

1. Measure inventory accuracy.
2. Track down suspected inventory errors.
3. Monitor critical or problem inventory items (e.g., pilferage or perishable items).

Audit trail transaction tracking is the process of reviewing all transaction activity on a part. This is used to visually spot unusual transactions (such as exceptionally high quantities or moves to unusual locations) and to review all transactions which could have caused a suspected or known inventory error (such as a part not located where it was reported to be located).

Error correction is the process of determining the cause of an inventory error and making necessary corrections. For example, some inventory errors may include:

1. Location errors.
2. Effectivity errors.
3. Flightworthiness status errors.
4. Part quantity on-hand errors.
5. Serial number errors.
6. Lot control number errors.
7. Part identification or tagging errors.
8. Picking errors.
9. Receiving errors.
10. Inspection errors.
11. Transaction recording errors.

Performance measurement is the monitoring of the overall performance of inventory (as affected by many functions such as engineering BOM accuracy, MRP, and purchasing) and inventory management and control activities. For example, some inventory

performance measurements would be:

1. Actual inventory cost (purchased, depreciated and value added) versus standard costs.
2. Inventory turns, which would be the actual or standard value of launched SRBs divided by the actual or standard inventory value (this valuation would be determined by NASA program costing).
3. Inventory shortage valuation, which would be the total cost of inventory shortages as a percentage of total cost of items disbursed. Shortages should be valued higher as the shortage ages. For example, if the shortage is three weeks old then the value of the shortage could be calculated as three times the standard cost of that component.
4. Inventory overage valuations which would be the total cost of inventory parts not allocated to a materials requirement plus inventory parts allocated but which will wait in inventory more than two to four weeks. This overage could be segregated into three classifications. These are:
 - (a) Purchase decision overages which may be caused by hedge buying or vendor minimum order requirements.
 - (b) Safety stock overages which are management decisions to maintain spares to protect against the risk of stock-out or part inspection rejections.
 - (c) Unplanned excess inventory.

The SRB production control environment requires that inventory control accommodate unique management control

requirements. These are serial number control, vendor production lot number control, part effectivity control, part flightworthiness control, serialized part life cycle management and control, "as built" configuration BOM and routing data pack tracking, and serialized part value added cost accumulation. Each of these is reviewed below.

Serial number control requires that a serial number controlled part be traceable throughout the inventory system. This includes item locations, all inventory transactions, audit control, and "as built" configuration data.

Vendor production lot number control requires that lot numbers be traced in a similar manner as serial numbers. However, it allows for the quantity per lot trace transaction to be greater than one.

Part number effectivity control requires that the effectivity of a serialized part become a suffix to the part number if the effectivity is upgradable to the higher effectivity. This suffix would be ignored by MRP so that a part of an alternate effectivity could satisfy the MRP requirement. The allocation of an alternative effectivity would trigger recommended upgrade shop order to affect the effectivity upgrade. This effectivity assignment would then require manual authorization prior to its release to CRP or dispatching. If an effectivity change is not upgradable then the part number itself should be changed, so that the system will not assume upgradability.

Part flightworthiness control requires that flightworthiness status be identified for each serialized part. This status could be rework required, test and disposition required, nonusable, or flightready. If the part is not flightready, then before it is allocated to an MRP requirement, a rework order will be triggered, and back-scheduled to plan the receipt of the part in flightready status.

Serialized part life cycle management and control requires that a part history summary follow the part. That is, the serialized part would be in the inventory file from its receipt from the vendor to its final disposition. Its useful life would be identified in number of flights or an expiration date. Actual activity would be tracked to signal life cycle action such as special tests or part expiration disposition. This method of life cycle management will facilitate projection of refurbishment requirements by updating part life for planned launches and expected refurbishment and relaunch time and by updating part life status.

"As built" configuration BOM and routing data pack tracking requires that serialized parts be assigned to a shop order and that assembled parts in inventory have an "as built" configuration BOM and routing associated with its buildup.

Serialized part, value added cost accumulation, requires that the "as built" configuration BOM and routing be costed to give part cost elements. For example, the following elements

would be included:

1. Materials costs.
2. Labor value added.
3. Labor overhead value added.
4. Facility equipment and GSE overhead value added.
5. Administrative overhead value added.

(g) Purchasing

Summary Narrative. Purchasing is designed to acquire materials needed to meet production requirements with the minimum inventory and purchase cost investment. These requirements will be communicated to purchasing through MRP net requirements and inventory policy material requirements (e.g., safety stock or spares inventory). The cost trade-off between inventory and purchase cost would be balanced by determining the cost of carrying inventory until required by production and by comparing this cost with the potential purchase cost savings from early or quantity purchases.

The purchasing system will assist management in the following ways:

1. Recommend purchase orders. The system will recommend the placement of a purchase order, based on production requirements and standard purchase data, such as minimum order quantities, primary vendor source, and vendor lead times. Purchasing will manually authorize, or change and authorize each recommended purchase order.

2. Determine vendor delivery schedule. The system will provide the date of a production requirement and the vendor delivery schedule performance. This gives the purchase order need date and the time buffer needed to ensure vendor delivery on time.

3. Identify inventory overages attributable to purchase decisions. The system will identify types of purchase decisions causing inventory to exceed production or inventory policy requirements. These types of decisions include:

- (a) Vendor minimum order quantities.
- (b) Hedge buying or early buys because of future price increases.
- (c) Quantity buys to take advantage of price breaks.

4. Facilitate vendor progress tracking. This will signal purchasing of vendor production milestones to be reported.

5. Facilitate purchase order expediting and deexpediting. The system will report purchase order status relative to production requirements and inventory policy requirements. It will also update vendor delivery targets. An exception purchase order status report will identify significantly early or late targeted deliveries.

These exception reports would also be generated to monitor open purchase orders where exceptions resulted from purchase decisions. Purchase decision types were discussed in a previous point.

6. Facilitate open purchase order coordination of late engineering change orders. The system will maintain a cross-reference of open "as designed" shop orders to open purchase

orders satisfying material requirements. Changes to the "as designed" will flag all open purchase orders affected through an exception report which also references the relevant change order.

7. Coordinate receiving of vendor deliveries. The system will authorize the receipt of vendor deliveries based on open purchase orders and approved delivery schedules.

8. Cross-check receiving accuracy. The system will provide a match of receiving reports to vendor invoices. Exceptions will be reported, signaling the need for manual error analysis.

9. Measure vendor performance. The system will monitor:

- (a) Vendor delivery performance.
- (b) Vendor product quality performance (inspection reports).
- (c) Vendor shipping error performance.
- (d) Vendor invoicing error performance.

The SRB production control environment requires that purchasing accommodate three unique purchasing requirements. These are vendor data pack information requirements, purchase requisitioning for fractional attrition requirements, and the return of parts to vendors for rework.

Vendor data pack information requirements require that the pertinent information be recorded in the "as built" configuration. This information will track the life of a serialized part or lot-controlled parts.

Purchase requisitioning for fractional attrition requirements requires that material be ordered to cover attrition requirement probabilities. Time-phased fractional requirements will be summed to determine the next purchase requirement. Caution must be exercised on parts where part effectivity or design attrition is high. This will require manual decisions on reordering.

Parts returned to vendors for rework require that vendor rework be treated as an off-site work center. The inventory locator system would locate the part in an MRP nonnetting location, and the production control system would generate a vendor rework shop order. This allows serialized part history tracking as well as vendor targeted delivery coordination. Receiving would receive parts on these vendor rework orders.

(h) Preventive
Maintenance

Summary Narrative. Preventive maintenance (PM) is designed to provide the capability to schedule PM shop orders at the same time as manufacturing shop orders are scheduled. The work centers, labor skills and resources required for PM will draw on the same resources used for manufacturing shop orders.

Capacity requirements planning and dispatching for PM will be handled together with manufacturing shop orders.

PM scheduling will recommend schedules with assigned priorities. Dispatching may adjust these schedules if the priority

allows. For example, if the PM shop order priority indicates that the work has to be done before a given date, then dispatching will attempt to schedule PM work when resources would otherwise be idle, but before the due date.

PM shop orders in a work center job queue will automatically queue based on work priority. For example:

1. If PM work is mandatory before a work center can work on any other task, the critical ratio will be fixed at "zero". This job will then automatically be set at the top of the priority queue.
2. If PM work is required before a specific date, then a normal due date will be set for the job. This job will then automatically advance in the priority queue as the due date approaches.
3. If PM work is to be done on a specific date, then a due date, start date and a special code will be set for the job. This job will then automatically advance in the queue priority but it will not be allowed to start before its start date.
4. If PM work is discretionary, such as optional work if idle time is available, then the critical ratio will be fixed at the highest number. This job will then remain at the lowest priority in the queue.

The uses of the standard shop order logic will facilitate:

1. PM scheduling.
2. PM resource requirements determination.

3. PM resource assignments.
4. PM performance monitoring.
5. PM costing.

Preventive maintenance shop orders will be treated as a different class of shop order, but will use the standard production control logic.

(i) Routing and Work
Authorization
Document Maintenance

Summary Narrative. Routing and work authorization document maintenance is designed to:

1. Provide detailed process instruction and buy-point documentation for production.
2. Define the sequence of operations to be performed on a shop order.
3. Identify the resources required to accomplish each operation.

The detailed process instructions are contained in OMIs and BOSSs. These work authorization documents (WADs) are extremely detailed step-by-step worker instructions with NASA and/or USBI quality assurance inspection sign-offs (buy-points) for many steps. This level of detail is not required for production control, but is required for instruction of production workers, as well as being required to support "data pack" buy-offs. WADs will be organized to follow the process flow of operations for assembly or manufacture. That is, a routings of operations, representing

WADs or WAD sections, will track the assembly or manufacture of each level in the bill of materials. There will be a routing for each parent level in the BOM. There will also be routings and WADs for upgrades of component effectivities and for rework and testing of spent components to flightworthy status.

WADs will change as the production processes and methods improve. Because of the WADs' detail and volume, the degree of change, the need for hard copy at the work site, and the need for WAD summaries to be used in the SRB/APC system, WADs for both KBAC and MBAC should probably be maintained on word processing equipment.

WAD summaries, or WAD section summaries, will become operations in the routing. The WAD contains the process information to support the operation.

WADs in the new APC routing environment do not need to contain parts lists, as these picking lists will be created and maintained in the BOM. The pick lists would accompany the parts to the work center and serve as an identity check upon installation. The original pick list would be returned to the work control station and become part of the data pack.

Resource requirements will be identified for each operation in the routing. These will include:

1. Work center (WC) where the work is to be performed and the time the WC is required.

2. Alternate WC for the operation if work can be performed at any other WC.

3. Other WC for operations which require neighboring WCs to be blocked. For example, hazardous operations would block a section of the production facility.

4. WC grouping such as a shop floor department or facility.

5. Labor skill certifications (L.C.) required to perform the work and the standard time required. If multiple workers of the same skill are required, then multiple requirements would be identified.

6. Alternate L.C. for the operation if a higher L.C. could be used to perform the work.

7. L.C. grouping such as a labor department or budget category (e.g., hydraulic engineering or electrical engineering).

8. Supplies needed during an operation (e.g., special clothing, screens, or curtains).

9. Tools, with the time needed.

10. GSE, with the time needed and the source.

11. Subcontractors, with the time needed.

The time required for each resource of an operation is critical to capacity planning. Work center duration and labor certification standard times, exploded for a time-phase production plan, will project the loads on each. Therefore, it is important that accurate resource timing be maintained.

Resource time maintenance will be an industrial engineering activity. Because of the low repetitiveness of operations, traditional time and motion standard time development may not be appropriate or cost effective. Therefore, initial "educated guess" benchmarks for "standard" times need to be analyzed and updated based on actual experiences. This makes it necessary that the SRB/APC system contain "as planned" and "as built" performance analyses and feed back these data to industrial engineering. Industrial engineering may then update time benchmarks based on actual results and learning curve projections.

The SRB production control environment requires that the routings accommodate six planning and control requirements.

These are:

1. Refurbishment operations routings and resource planning.
2. Configuration and data pack operations tracking.
3. Routing operations network structuring.
4. Preventive maintenance routing for GSE.
5. Off-standard and nonproductive work tracking.
6. Exception operations for problem resolution or process changes (e.g., TPS/PR/DRs).

Refurbishment operations routings require that the routings follow three stages of development. These stages are:

1. Fractional resource load routing based on the forecasted attrition BOM.

2. "Semifirm" routing of part fractional resource loads and firm loads based on component life expiration or rework projections and on component effectivity upgrade rework needs.

3. Post-test, firm routing of all component disassembly and replacement installations.

The staged refurbishment routing will be tied to the attrition BOM. The forecasted attrition rates of an LRU will be associated with the assembly installation kit of parts. This BOM kit attrition will be associated with the LRU dismantling operations and replacement installation operations of the refurbishment routing. The attrition rate (e.g., 20% probability of replacement) is exploded through the operations resource requirements to give a planned loading of resource capacity. Although only a percentage of the operation resources is projected, summing these will be the best estimate of resource needs and work duration. To exclude refurbishment work resource requirements would grossly understate time-phased resource capacity loads. Similarly, the inclusion of all possible refurbishment work resource requirements would grossly overstate time-phased resource capacity loads. The attrition loaded routing, although a statistical guess, is the most plausible tool for forecasting resource capacity loading.

The next stage is firming the refurbishment routing, and resource capacity loading can be achieved weeks or months ahead of refurbishment for components requiring effectivity upgrades or replacement due to component life expiration.

The final stage of firming the refurbishment routing is accomplished after testing of the major assembly, upon recovery of the SRB. Test results will signal the need to replace components. This will trigger deletion of attrition resource projections for components not replaced, and firm up operations full resource requirements for components being disassembled and replaced.

Configuration and data pack operations tracking requires that the actual routing operations sequence and resource usage be recorded. This will allow later comparisons to the planned routing and resource requirements. This capability is required for many reasons. For example:

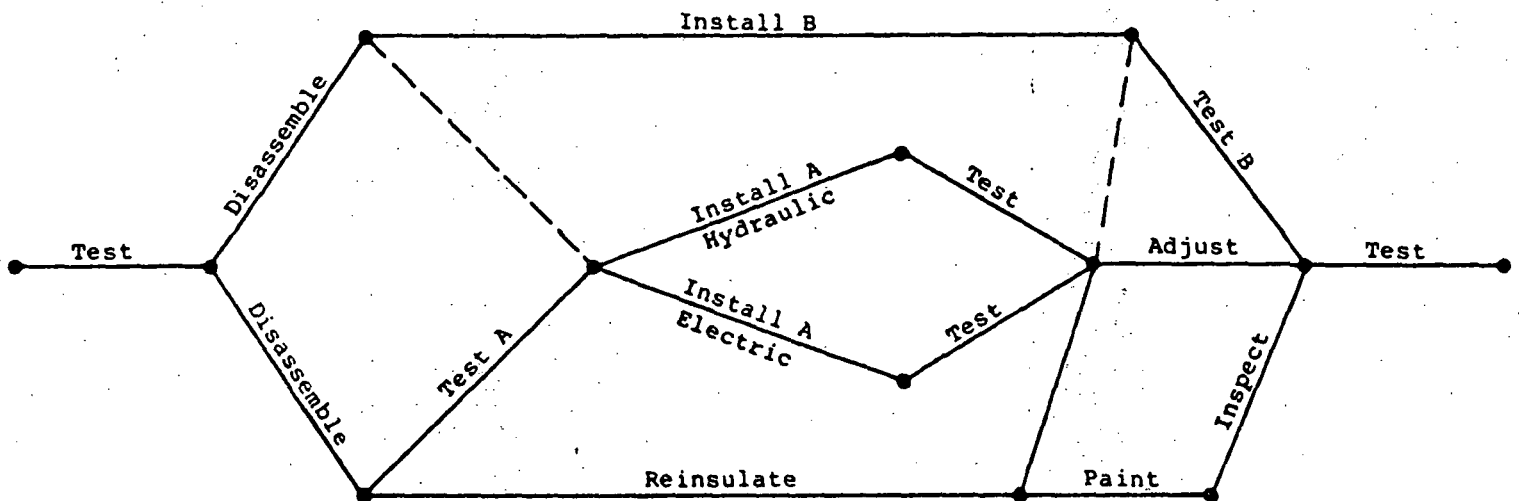
1. To provide industrial engineering activities with actual resource usage by operation.
2. To monitor actual production value added against standards.
3. To track exceptions to planned routing operation sequences or to planned resource requirements so that "buy-off" analysts can identify exceptions which may require detail analysis of hard copy WADs. This assumes that "buy-off" analysts will accept that qualified inspector OMI buy points have been validated by qualified document inspection authority at the work control station.
4. To track exceptions so that industrial engineering can identify potential or required process instruction changes.
5. To identify partially complete routings where the effectivity upgrade might not be fully completed. For example,

routing operations may be classified as mandatory or optional; therefore, optional operations (such as weight or cost reduction engineering charges) may be excluded. These upgraded components may be flightworthy but not fully upgraded to the new effectivity.

6. To record effectivity improvements to a previous "as built" configuration of a flightworthy part of a lower effectivity.

Routing operations network structuring requires that operations sequencing within a routing be structured similarly to a CPM/PERT network. For example, Figure IV-2 shows a hypothetical refurbishment routing.

Figure IV-2
Refurbishment Routing XYZ



This network operation structure for routings will facilitate production control for the following activities:

1. Parallel work operations for one routing. These could be WADs for different engineering operations which can be performed at the same time on the same shop order routing.
2. Multiple paths of refurbishment operations routings which disassemble components for parallel testing or rework in back shop operations.

Preventive maintenance routings for GSE and buildup stands require that these operations be recorded in the same form as shop order routings and resource requirements identified. Part master numbers would be reserved to facilitate scheduling control (using the same method as production scheduling) and to facilitate preventive maintenance cost tracking (part master value added information).

Off-standard and nonproductive work tracking requires special category part master numbers and dummy shop order routings. Whenever unusual or nonstandard work (e.g., cleanup or idle time) occurs, the time would be recorded against a special category shop order. Actual time would be recorded against the dummy shop order and value added recorded against the part number. Monthly or periodic reporting would be able to record the occurrence and cost of these exceptions by category.

Exception operations for problem resolution or process changes (e.g., TPS/PR/DRs) require the addition of an operation

to the shop order routing. This may also include the disassembly and reinstallation of any component. Exception parts used would be recorded against the shop order and exception resources used recorded against the routing operation of the shop order. Configuration delta lists would highlight these exceptions to industrial engineering which would be responsible for effecting any WAD changes or any manufacturing BOM changes necessary, and for alerting design engineering of any engineering BOM changes necessary.

(j) Configuration Management

Summary Narrative. Configuration management is designed to provide the capability to compare "as built" materials and work performed to "as designed" materials and "as planned" work structures.

Comparisons of "as built" work performed versus "as planned" work structures is currently conducted through the data pack buy-off analysis. Within the automated production control environment for the SRB operations phase, this could be simplified. The simplified data pack buy-off could be a comparison of the "as planned" routing to the "as built" work performed. This automated assist to data pack comparison could produce a delta list identifying the following.

1. Routings with operations not having proper WAD buy point authorizations.

2. Operations sequence changes and shop floor supervisor inspector notes of reasons for the change.

3. Operations with alternative work centers and shop floor supervisor or inspector notes of reasons for the change.

4. Operations with alternative labor skill certifications used, and notes.

5. Operations with alternative special resources (e.g., supplies, tools, GSE and subcontractors) used, and notes.

6. Operations deleted and notes.

7. Operations added with cross-references to PRs, DRs, or other exception WADs, and notes.

It should be noted that LRU dismantle and reinstallation for any reason would require additional operations to be incorporated to the routing.

8. Standard time variance analysis for operation time at a work center.

9. Standard time variance analysis for operation time work by labor skill.

This data pack buy-off could be required to close a shop order; therefore shop orders with no work remaining will be queued for a buy-off decision.

Comparisons of "as built" materials versus "as designed" is a comparison of the bill of materials for a part effectivity to the actual materials used. This requires "as built" configuration part information such as:

1. Part effectivity.

2. Part flightworthiness status.
3. Part life cycle history.
4. Part source, (vendor) information.
5. Part serial number.

Materials configuration comparisons could generate materials delta reports. These reports could be used for the following purposes.

1. To assist in buy-off analysis.
2. To compare "as designed" configurations across multiple effectivities.
3. To compare "as designed" requirements to "as built" configurations of spent major assemblies to be refurbished. This analysis could identify components to be disassembled for design modifications or life cycle reasons.

Effectivity management and life cycle management require that configuration management have the capability to initiate the "as built" data capture during the prerelease assignment of serialized parts to a specific shop order.

For each manufactured and serialized part in inventory, an "as built" configuration could be maintained. This configuration should be readily accessible (e.g., on-line) to engineering, effectivity management, life cycle management, quality assurance, and production control.

It is, however, anticipated that the level of detailed

information maintained by the APC system would not be sufficient for NASA's current needs and that if those specific needs continue, ACMS or an equivalent would be necessary.

(k) Labor Control

Summary Narrative. Labor control is designed to track labor applied to a shop order or other work categories.

This will facilitate productivity and cost analysis. Some labor productivity and cost analysis capabilities are:

1. Work task and worker standard time variance or productivity analysis.
2. Worker utilization analysis (percentage of time on standard work).
3. Labor department productivity analysis.
4. Department utilization.
5. SRB direct labor variance analysis.
6. Inventory labor value-added analysis.
7. Data collection to interface with PMS analysis.

SUBSYSTEM OBJECTIVES

The automated production control system is composed of the subsystems described in the previous section. Each of the six key subsystems (highlighted in the System Overview Flowchart, Figure IV-1) are further described in this section. The key subsystem specifications which follow are intended to support and further amplify the previous descriptions. Each of the subsystems is described in the following manner:

1. Subsystem flowchart.
2. Key subsystem narrative.
3. Key input source definition and data elements.
4. Key output definitions and data elements.

Identification of data elements is limited to the name of the data elements. More detailed descriptions of each data element, such as field size and data type, are found in Section V, Computer Systems Requirements. The numbers in the text correspond with the accompanying subsystem flowchart.

(a) Master Scheduling

The master scheduling subsystem defines a two-level master production schedule. The first level defines the final assembly (stacking) and check-out of the SRBs (KBAC Operations) based upon launch schedules provided by NASA. The second level defines the major components (aft skirt, frustum, etc.) and parts kits required for aisle transfer in order to meet the launch schedule (MBAC). This subsystem "pegs" the two levels; i.e., traces the major

component requirements back to the discrete stocking shop order in order to maintain total SRB refurbishment/subassembly/stacking schedule integrity.

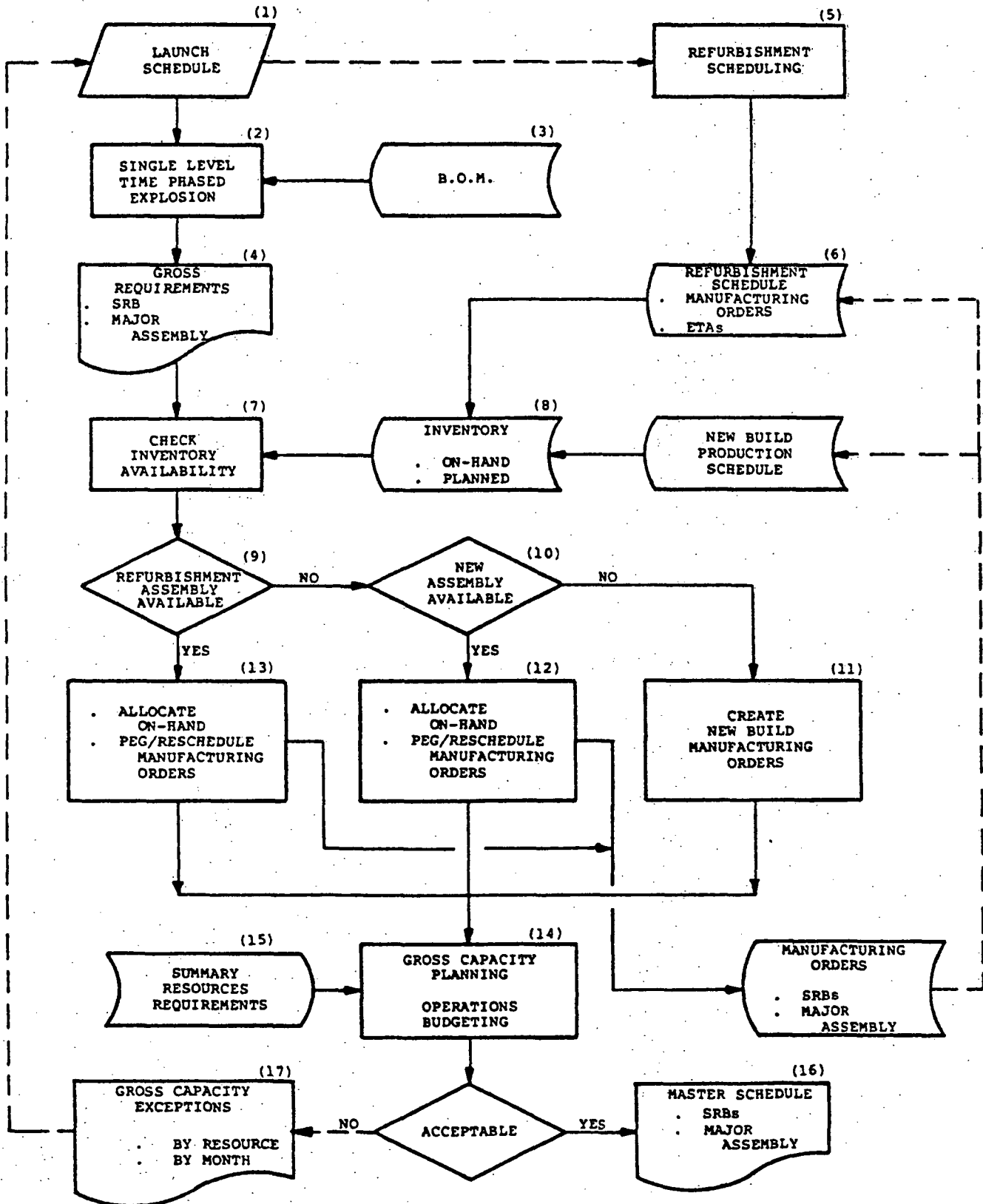
1. Subsystem Narrative. The flowchart shown in Figure IV-3 indicates the primary subsystem logic. Launch schedules (1), provided by NASA are used for two purposes. First, a single level, time-phased explosion (2) of major components is developed for KBAC, considering the estimated time required for each stacking and check-out operation. The manufacturing bill of materials (3) is used for this explosion. The result of this activity is a time-phased major component, gross requirements schedule (4) (not considering major components already in the system of MBAC).

Second, the launch schedule drives a refurbishment schedule (5) which is the anticipated due date of refurbished major components. This planning phase (6) is based on the cycle times for recovery, cleaning and disassembling (KBAC), and refurbishment and subassembly (MBAC).

Next a "netting" activity (7) takes place via an inventory file (8) (on-hand and planned) where gross requirements are compared to on-hand or planned inventory receipts in order to determine if a refurbished component is available or planned to be available (9). If a refurbished major component is not available or planned to be available, the subsystem will check the availability of a new assembly (10). If a new assembly is not available, a new build manufacturing order (11) will be created for the assembly of the major component. If a new assembly is

Figure IV-3

Master Scheduling Subsystem



available, the subsystem will allocate (reserve) on-hand major components and reschedule the open manufacturing orders (12) in order to comply with the new assembly requirement.

If in the "netting" and inventory checking activity a refurbished major component is available, it is reserved and re-revised schedules are created to comply with the time requirement (13).

Based on requirements for refurbished components (13), new components already available (12) and new components which must be created (11), a gross capacity check is made (14). This is accomplished by adding the time-phased requirements for key resources (labor, materials, facilities, GSE, etc.) and comparing these capacity requirements to a summary file of resources available (15) in order to determine if "gross capacities" have been exceeded. If they have not been exceeded, the master schedule is assumed to be acceptable and a "verified" master schedule is created (16). If the preceding logic will not produce a verifiable master schedule, an exception report (17) will be generated indicating that gross capacity for a specific resource (e.g., Hot Fire Test Facility), is exceeded and that the launch schedule (1) as defined cannot be met.

2. Key Input Source and Data Elements. Figure IV-4 shows a summary of the key inputs required for the Master Scheduling Subsystem. The "topical reference" refers to the major subsystem input indicated on the flowchart.

Table IV-2 indicates the key data elements associated

Figure IV-4
Master Scheduling Subsystem

Input Summary

<u>Topical Reference</u>	<u>Source of Data</u>	<u>Originator of Data/ Location</u>	<u>Estimated Frequency</u>	<u>Volume</u>		<u>Where Used</u>
				<u>Per Frequency</u>	<u>Annual</u>	
Launch Schedule	Manual Input (later file)	NASA/MSFC	As Required	200 Flights 200 Records	As Required	Major Assembly Requirement Refurbishment Schedule
Major Assembly Manufacturing Bill of Material	File Extract	Manufacturing Process- Industrial Engr./ USBI-HSV	As Required	30 Major Assembly 30 Records	As Required	Major Assembly Requirement
Major Assembly Inventory . On-Hand . Planned	File Extract	Calculation/ within Computer	As Required	200 Flights Sets 30 Records/Set 6,000 Records	As Required	Major Assembly Availability
Summary Resource Requirement (Planning Resource Bill)	File	Resource Planning/ USBI-HSV	As Required	30 Bills 30 Records	As Required	Gross Capacity Requirements Checks
Summary Resource Availability (availability plan)	File	Resource Planning/ USBI-HSV	As Required	80 Resource Types 60 Months 4,800 Records	As Required	Gross Capacity Requirements Check

Table IV-2Master Scheduling SubsystemKey Input Data Element

<u>Subsystem Input</u>	<u>Key Data Element</u>
Launch Schedule	Launch Number Launch Date
Manufacturing Bill of Material Extract	Part Number Part Description Final Assembly Lead Time
Inventory (On-Hand and Planned)	Part Number Quantity On-Hand/Planned Due Date (If Planned)
Summary Resource Availability (Planning Resource Bill)	Major Assembly Number Major Assembly Description Resource Number (Type) Resource Description Resource Quantity Needed by Time Unit of Measure
Summary Resource Availability (Availability Plan)	Resource Number (Type) Resource Description Resource Quantity Needed by Time Unit of Measure

with each of the inputs identified.

3. Key Output Definitions and Data Elements. Figure IV-5 shows a summary of the key outputs provided by the Master Scheduling Subsystem. The "subsystem output" reference refers to either a report, CRT screen, file update or a combination of the three.

Table IV-3 indicates the key data elements associated with the subsystem output.

Figure IV-5
Master Scheduling Subsystem

Output Summary

Subsystem Output	Frequency	Estimated Volume		Period Covered	Report Sequence	Distribution/ Location
		Lines	Pages			
Major Assembly Gross Requirements	As Required	6,000	120	5 years	Aisle Transfer • Major Component Major Component • Aisle Transfer Date	• Resource Planning/ USBI-HSU • Production Control/ USBI-KSC
Major Assembly Manufacturing Orders	As Required	6,000	120	5 years	Major Assembly • Due Date Due Date • Major Assembly	• Resource Planning/ USBI-HSU • Production Control/ USBI-KSC
Master Schedule	As Required	6,000	120	5 years	Major Assembly • Due Date Due Date • Major Assembly	• Resource Planning/ USBI-HSU • Design Engineer/ USBI-HSU • Process Engineer/ USBI-RSC • Production Control/ USBI-KSC
Gross Capacity Exceptions	As Required	Less than 4,800	Less than 100	5 years	Resource Type • Month Month • Resource Type	• Resource Planning USBI-HSU • As Required

Table IV-3Master Scheduling SubsystemKey Output Data Elements

<u>Subsystem Output</u>	<u>Key Data Element</u>
Major Assembly Gross Requirement	Major Assembly Number Major Assembly Description Major Assembly Due Date
Major Assembly Manufacturing Order	Major Assembly Number Major Assembly Description Major Assembly Serial Number Major Assembly Due Date STS Flight Number Order Type (Refurbishment or New)
Master Schedule	Major Assembly Number Major Assembly Description Major Assembly Serial Number Major Assembly Due Date STS Flight Number Order Type (Refurbishment or New)
Gross Capacity Exceptions	Resource Number Resource Description Resource Quantity Required Resource Quantity Available Resource Quantity Over Gross Capacity

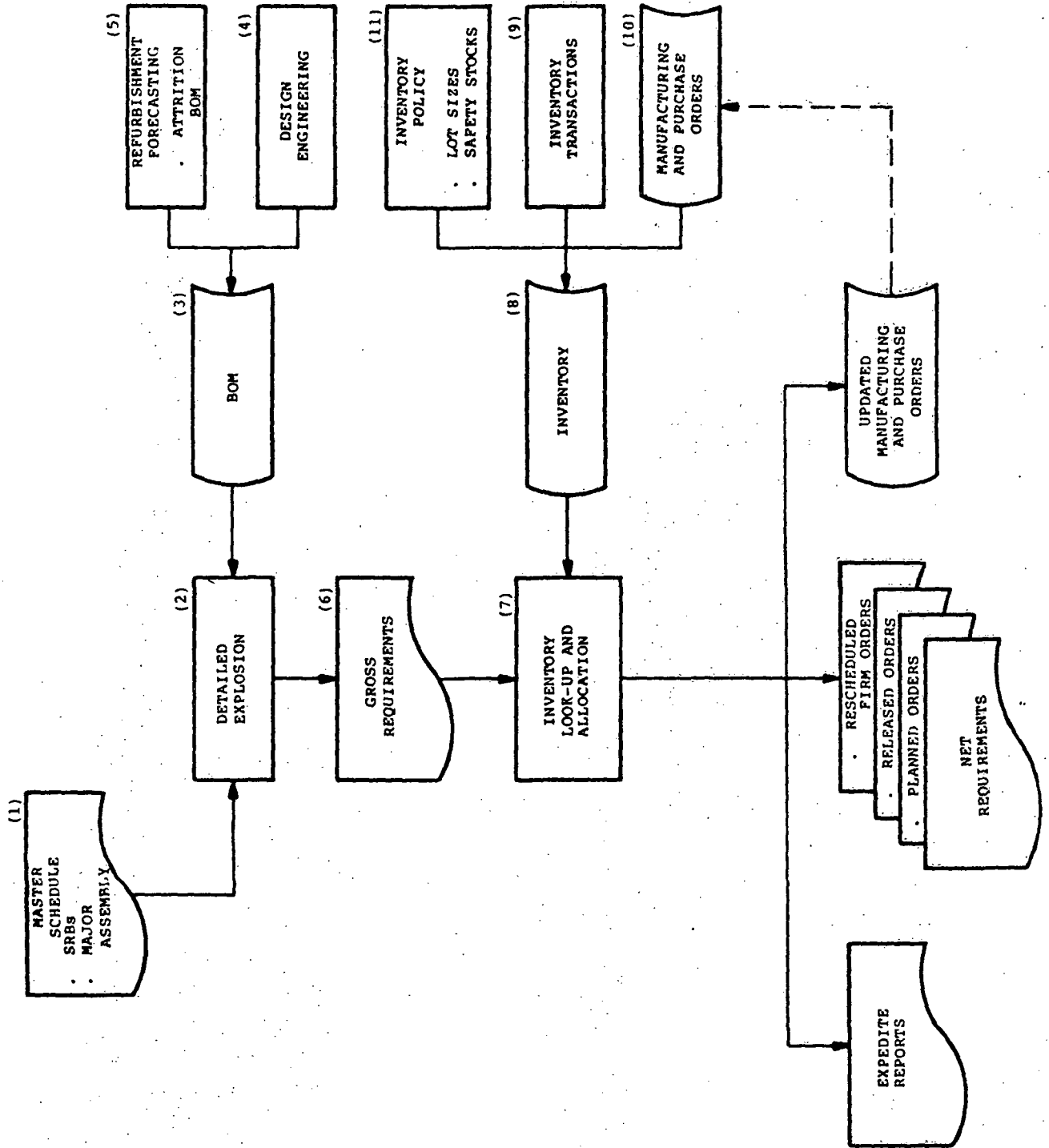
(b) Material
Requirements
Planning

The material requirements planning subsystem (Figure IV-6) uses the master schedule in order to further define the detailed requirements of MBAC. These requirements, based on aisle transfer dates, will be in the form of time-phased schedules for refurbishment and subassembly activities needed in order to meet those aisle transfer dates.

1. Subsystem Narrative. The "verified" master schedule (1) generated in the Master Scheduling Subsystem is passed to the Material Requirements Subsystem for a detailed explosion (2) of the major components (aft skirt, etc.) into the subassemblies, LRUs, etc., required to meet the aisle transfer dates. This detailed explosion process uses the manufacturing bills of material (3), developed from the engineering design (4), as well as forecasted attrition (5) based on historical occurrences. Quality assurance will also provide estimates for the attrition bills of material in the form of forecasted attrition rates by assembly or subassembly.

The output of the detailed explosion is the gross requirements (6) of each assembly, subassembly, or LRU. These gross requirements are compared (7) to available and planned inventory (8) in order to determine net parts requirements (parts needed but not on-hand or planned). The inventory file is maintained based on inventory transactions (9) from receiving, purchasing (planned receipts), as well as receipts and disbursements from the various stocking locations (10).

Figure IV-6
Materials Requirements Planning Subsystem



Inventory policies (11) relating to such things as safety stocks, etc., are also used.

In addition to the net requirements being provided by the inventory netting calculation, planned orders, rescheduled firm orders, released orders, requests for purchase orders and expedite reports are also generated.

2. Key Input Sources and Data Elements. Figure IV-7 shows a summary of the key inputs required for the Material Requirements Planning Subsystem. The "topical reference" refers to the major subsystem input indicated on the flowchart.

Table IV-4 indicates the key data elements associated with each of the inputs identified.

3. Key Output Definitions and Data Elements. Figure IV-8 shows a summary of the key outputs provided by the Material Requirements Planning Subsystem. The "subsystem output" reference refers to either a report, CRT screen, file update or a combination of the three.

Table IV-5 indicates the key data elements associated with the subsystem output.

Figure IV-7

Material Requirements Planning Subsystem

Input Summary

Topical Reference	Source of Data	Originator of Data/ Location	Estimated Frequency	Volume		Where Used
				Per Frequency	Annual	
Master Schedule	From Master Scheduling Subsystem	Computer	As required	200 Flight Sets 30 Records/Set 6,000 Records	As Required	Detailed Explosion
Manufacturing Bill of Material	File	Design Engr., Quality assurance/ USBI-IISV	Maintenance as Required			Detailed Explosion
Inventory	File	Process Engr./ USBI-KSC	Used Daily (net change)			
		Inv.-transactions/ USBI-KSC Purchasing/ USBI-IISV Management/ USBI-IISV (safety stock)	Perpetual	3,200 Issues/Day 3,200 Receipts/Day 3,200 Inspect./Day 3,200 adj./Day <u>12,800/Day</u>	4,000,000	Inventory Netting And Allocation Logic
		Computer calculation				

Table IV-4Material Requirements Planning SubsystemKey Input Data

<u>Subsystem Input</u>	<u>Key Data Element</u>
Master Schedule	Major Assembly Number Major Assembly Description Major Assembly Serial Number Major Assembly Due Date STS Flight Number Order Type (Refurb or New)
Manufacturing Bill of Material	Parent Part Number Component Part Number Quantity Used Unit of Measure Effectivity (STS Numbers) Engr. Change Number Engr. Change Date Drawing Number Find Number
Inventory	Part Number Part Description Effectivity Class Code ABC Code Source Code Unit of Measure Inventory Account Number Reorder Point Reorder Policy Data Last E.O. Change Number Quantity on Hold Safety Stock Part Status

Figure IV-8
Material Requirements Planning Subsystem

Output Summary

Subsystem Output	Frequency	Estimated Volume		Period Covered	Report Sequence	Distribution/Location
		Lines	Pages			
Net Requirements (shop & P.O. requests) • Planned Orders • Rescheduled Firm Orders • Released Orders	Daily - net change	1,000	20	Daily	Part number • Due date • Part number	Purchasing/USBI-HSV Production Control/ USBI-KSC Inventory Control/ USBI-KSC
Expedite/Deexpedite Report	Daily	200	5	Daily	Part number • Due date • Order number	Purchasing/USBI-HSV Production Control/ USBI-KSC Inventory Control/ USBI-KSC
Manufacturing Orders	Daily	1,000	20	Daily	Part number • Due date • Order number	Purchasing/USBI-HSV Production Control/ USBI-KSC Inventory Control/ USBI-KSC

Table IV-5Material Requirements Planning SubsystemKey Output Data Elements

<u>Subsystem Output</u>	<u>Key Data Element</u>
Net Requirements	Part Number/Serial Number Part Description Quantity Required by Date Quantity Required by Requirement Number Quantity Allocated by Requirement Number Planned Receipt Date Planned Receipt Quantity Order Status (planned, firm, released) Order Number Launch Number
Expedite Report	Part Number/Serial Number Part Description Quantity Required by Date Quantity Required by Requirement Number Quantity Allocated by Requirement Number Planned Receipt Date Planned Receipt Quantity Order Status (planned, firm, released) Order Number Launch Number
Manufacturing Orders	Part Number/Effectivity Planned Quantity Due Date Start Date Launch Number Next Higher Assembly

(c) Capacity
Requirement
Planning

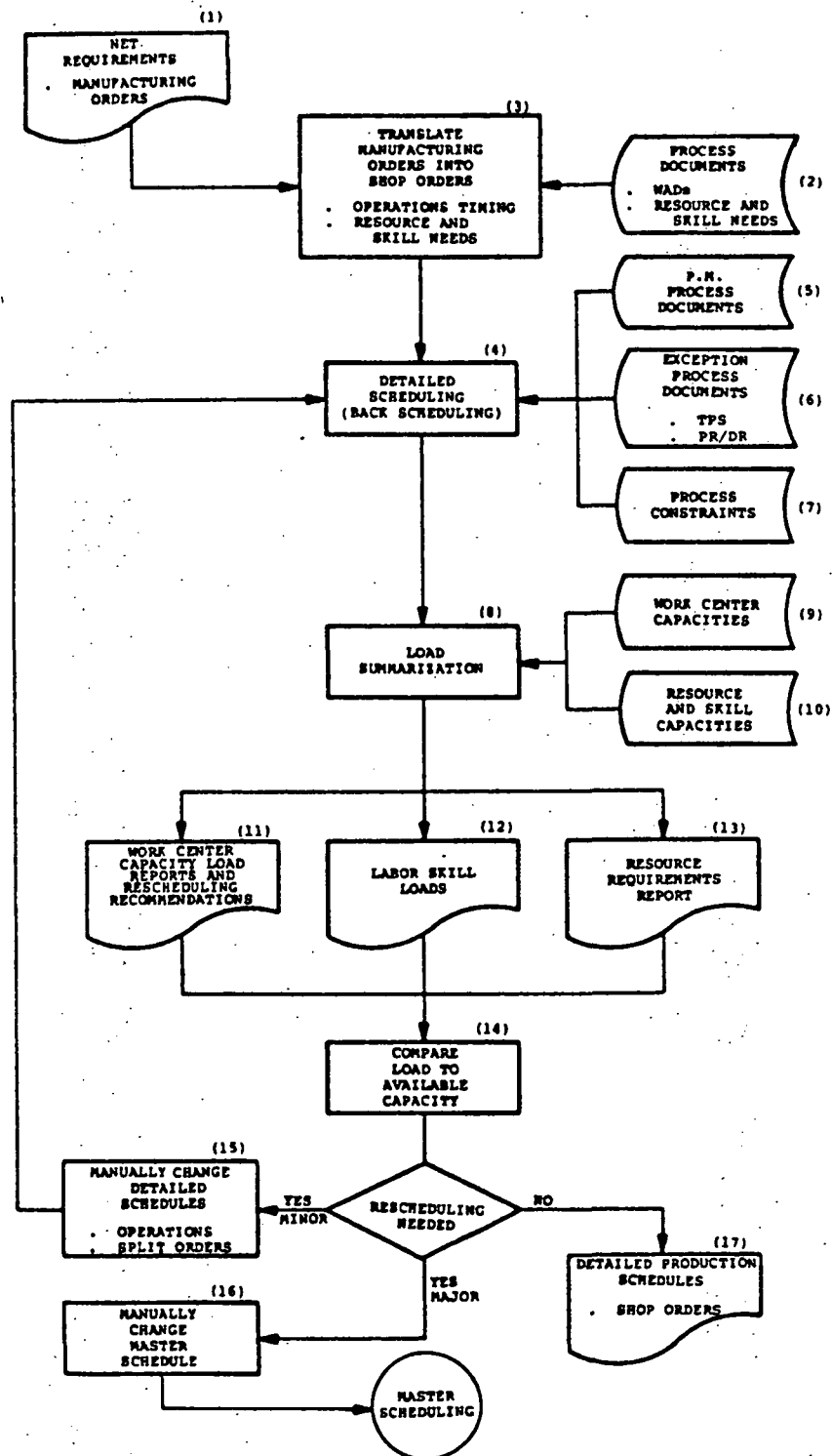
The capacity requirements planning subsystem (Figure IV-9) provides the information necessary to identify capacity constraint overloads and help management resolve such conflicts. Capacities for key resources are loaded based on schedule requirements and overloads are noted by resource. Resources include work centers, labor certification, GSE unique to USBI, and major tools. When overloads are identified, the overloaded resource will be noted, in addition to all the activities, by operation number, contributing to that overload.

1. Subsystem Narrative. Manufacturing orders (1) from the Material Requirements Planning Subsystem will be passed to this subsystem. Routing data (2) are combined in an activity which translates manufacturing orders into shop orders (3) by operation times and resource needs. This translation is then used to develop a detailed schedule (4) through the incorporation of GSE preventive maintenance process documents (5) exception process documents (e.g., TPSs, PR/DRs, etc.) (6), as well as process constraints (7).

Detailed schedules are then converted to load summaries (8) by using work center capacities (9) and resource skill capacities (10) in order to provide capacity load reports (11), labor load reports (12), and resource requirements reports (13). These reports, which include capacities of each resource (e.g., work centers, etc.) will be used by management (14) to determine

Figure IV-9

Capacity Requirements Planning Subsystem



if major or minor rescheduling is required. If minor rescheduling is required, manual changes (15) to the detailed schedule are input. If, however, major rescheduling is required, management will have to make changes to the master schedule (16).

If rescheduling is not needed due to capacity overloads, detailed production schedules (17) can then be released.

2. Key Input Sources and Data Elements. Figure IV-10 shows a summary of the key inputs required for the Capacity Requirements Planning Subsystem. The "topical reference" refers to the major subsystem input indicated on the flowchart.

Table IV-6 indicates the key data elements associated with each of the inputs identified.

3. Key Output Definitions and Data Elements.

Figure IV-11 shows a summary of the key outputs provided by the Capacity Requirements Planning Subsystem. The "subsystem output" reference refers to either a report, CRT screen, file update, or a combination of the three.

Table IV-7 indicates the key data elements associated with the subsystem output.

Figure IV-10

Capacity Requirements Planning Subsystem

Input Summary

Topical Reference	Source of Data	Originator of Data/ Location	Estimated Frequency	Volume		Where Used
				Per Frequency	Annual	
Manufacturing Orders	From Material Requirements Planning Subsystem	Computer Generated	Weekly or as Required	20 Flights (6 months) "x" Routing Sheets/ Flight "20x" Records 5% per Day	To Be Determined	Manufacturing Order Translation
Routing	File	Processing-Engr./ USBI-KSC	Daily	20 Flights 800 OMIs "x" Routings/ Effectivity 20 x" Max Records 5% per Day	To Be Determined	Manufacturing Order Translation
GSE Preventive Maintenance Process Documents	File	Preventive Maintenance - USBI-KSC	Daily as Required	500 P.M. OMIs 1 Routing/OMI 500 Records 5% per Day	To Be Determined	Detailed Scheduling
Exception Process Documents	File	Shop floor/ USBI-KSC Processing-Engr./ USBI-KSC	Daily	20 Flights 200 per/sts 25 Records per Day	7,800	Detailed Scheduling
Process Constraints Documents	File	Processing-Engr./ USBI-KSC	As required	Same as Routing	To Be Determined	Detailed Scheduling
Work Center Capacities	File	Processing-Engr./ USBI-KSC	As required	100 Work Centers To Be Determined	To Be Determined	Detailed Scheduling
Resource and Skill Capacities	File	Processing-Engr./ USBI-KSC	As required	80 Resource Types "x" Resources/Type 80 "x" Records 5% per Day	To Be Determined	Detailed Scheduling

12 1 0

Table IV-6Capacity Requirements Planning SubsystemKey Input Data Elements

<u>Subsystem Input</u>	<u>Key Data Element</u>
Manufacturing Orders	Part Number/Effectivity Planned Quantity Due Date Start Date Launch Number Next Higher Assembly
Routings	Fill from CSR Sheet
GSE Preventive Maintenance Process Documents	Fill from CSR Sheets for Routing without Setup
Exception Process Documents	Fill from CSR Sheets for Routing without Setup
Process Constraints	Part Number/Routing Number Operation Code Network Structure Code
Work Center Capacities	See CSR Sheet for WCC
Resource and Skill Capacities	Resource Number Resource Description Same as WCC from CSR

Figure IV-11
Capacity Requirements Planning Subsystem

Output Summary

<u>Subsystem Output</u>	<u>Frequency</u>	<u>Estimated Volume Lines</u>	<u>Estimated Volume Pages</u>	<u>Period Covered</u>	<u>Report Sequence</u>	<u>Distribution/ Location</u>
Work Center Capacity Load Reports and Reschedule Recommendations	Weekly or as Required	1,000 or	30	6 Months	Department/ Work Center	Production Control USBI-KSC
		Graphic or	100	6 Months	Department/ Work Center	Production Control USBI-KSC
		Exception	20	6 Months	Most Critical Exception	Production Control USBI-KSC
Labor Skill Loads	Weekly or as Required	1,000 or	30	6 Months	Department/ Labor Skill	Production Control USBI-KSC
		Graphic or	100	6 Months	Department/ Labor Skill	Production Control USBI-KSC
		Exception	20	6 Months	Most critical Exception	Production Control USBI-KSC
Resource Requirements Reports	Weekly or as Required	5,000	100	6 Months	Resource Type/ Resource Number Requirement	Production Control USBI-KSC
Detailed Production Schedules	Weekly or as Required	20,000	400	6 Months	Shop Order/ Operation	Production Control USBI-KSC

Table IV-7Capacity Requirements Planning SubsystemKey Output Data Elements

<u>Subsystem Output</u>	<u>Key Data Element</u>
Work Center Capacity Load Reports and Reschedule Recommendations	Work Center Department Work Center Number Work Center Description Work Center Capacity Work Center Load Time Period
Labor Skill Loads	Labor Department Labor Skill Certification Code Labor Skill Certification Description Labor Skill Certification Capacity Labor Skill Certification Load Time Period
Resource Requirements Reports	Resource Group Resource Code Resource Description Resource Requirement Time Time Period
Detailed Production Schedules	Shop Order Number Part/Effectivity/Serial Number Operation Operation Start Date Operation Due Date Quantity Resources

(d) Shop Floor
Management

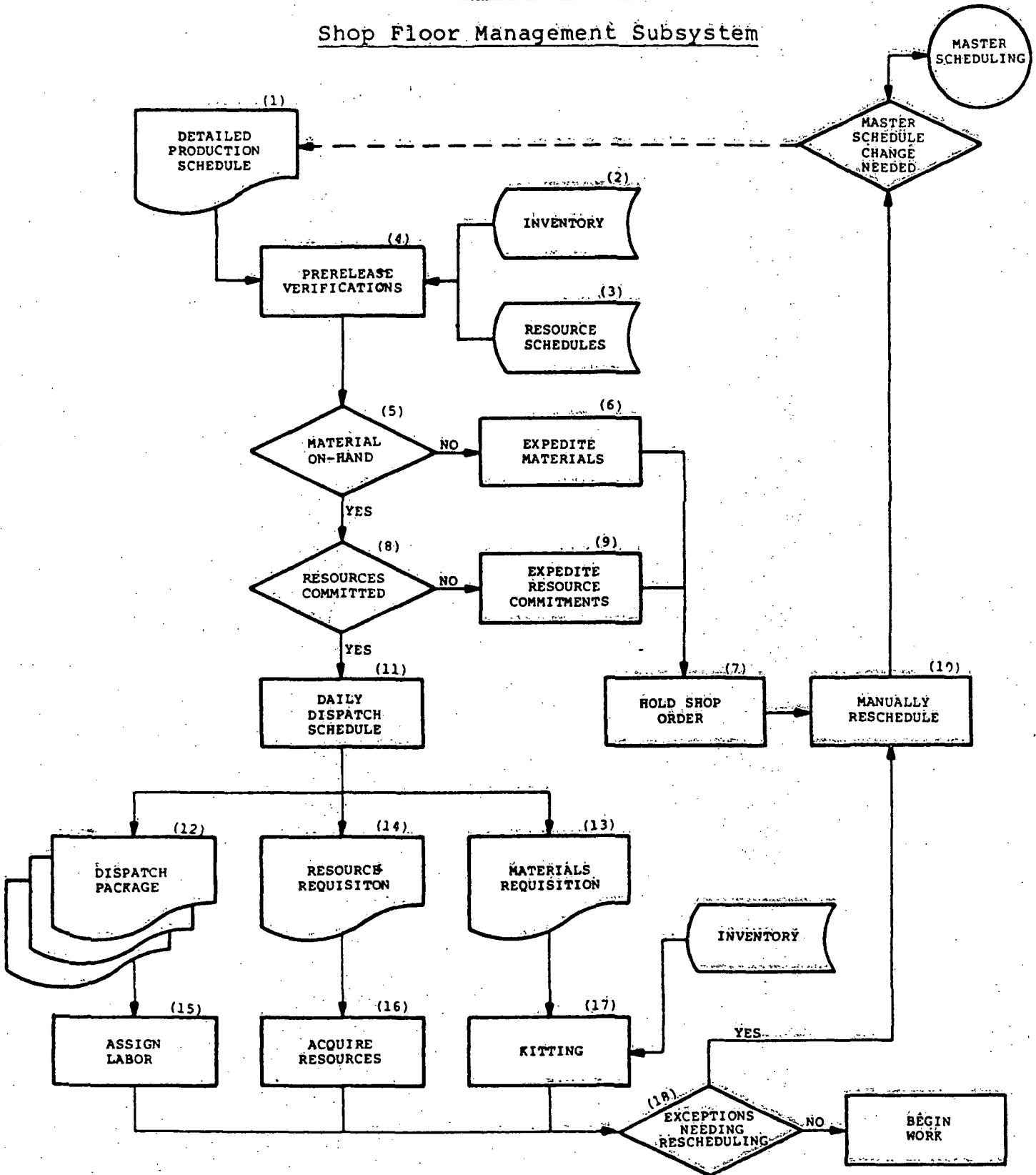
The shop floor management subsystem (Figure IV-12) has two primary functions. First, is the preverification of all resources needed for completion of a shop order. These resources include material and parts, labor, GSE and tools, etc. This is the final check for "floor availability" before a shop order is released.

Second, the subsystem actually releases the shop orders to the work control stations for subsequent release to the work centers, along with other paperwork from the word processing center, such as OMIs, BOSSs, etc.

1. Subsystem Narrative. Detailed production schedules (1) from the Capacity Requirements Planning Subsystem are passed to this subsystem where inventory data (2) and resource schedule information (3) are combined to provide a final check (4) of "floor availability". The logic provides for a material on-hand verification (5) where if material is not physically available, a material expedite (6) is created and the shop order is placed "on hold" (7). If material is available, a check is then made for the current availability of other resources (8) such as labor by certification, GSE by hours, etc. If any of these resources are not available, a resource expedite (9) is created and the shop order is placed on hold (7). Shop orders that are placed on hold due to material or resource shortages must be manually rescheduled (10) when the nonavailable item becomes available. If all material and resources are found to be available, shop orders are created

Figure IV-12

Shop Floor Management Subsystem



at the work control stations along with a daily dispatch schedule (11).

A dispatch package (12) will be provided along with material (13) and resource requisitions (14). Labor may then be assigned (15), GSE and other resources (16) may then be acquired and parts kitting (17) may then be accomplished.

A final check (18) is made prior to the actual start of work to make sure that all requirements are "in hand".

2. Key Input Source and Data Elements. Figure IV-13 shows a summary of the key inputs required for the Shop Floor Management Subsystem. The "topical reference" refers to the major subsystem input indicated on the flowchart.

Table IV-8 indicates the key data elements associated with each of the inputs identified.

3. Key Output Definitions and Data Elements. Figure IV-14 shows a summary of the key outputs provided by the Shop Floor Management Subsystem. The "subsystem output" reference refers to either a report, CRT screen, file update, or a combination of the three.

Table IV-9 indicates the key data elements associated with the subsystem output.

Figure IV-13

Shop Floor Management Subsystem

Input Summary

<u>Topical Reference</u>	<u>Source of Data</u>	<u>Originator of Data/ Location</u>	<u>Estimated Frequency</u>	<u>Volume per Frequency</u>	<u>Annual</u>	<u>Where Used</u>
Detailed Production Schedule	File	Computer Generated Dispatching and Operations Control USBI-KSC	Daily	100 Work Centers 20 Operations in Each Queue 2,000 Records	To Be Determined	Dispatch Package
Inventory	File	Inv. Qty. Available USBI-KSC	Perpetual	To Be Determined	To Be Determined	Materials On-Hand Daily Dispatch Schedule Pick List Kitting
Resource Schedule	File	Computer Generated	Daily	2,000 Operators 10 Resources per Operation 20,000 Records	To Be Determined	Resource Commitments Dispatch Package Resource Requisitions

Table IV-8Shop Floor Management SubsystemKey Input Data

<u>Subsystem Input</u>	<u>Key Data Element</u>
Detailed Production Schedule	Shop Order Number Part Effectivity/Serial Number Operation Operation Start Date Operation Due Date Quantity Resources
Inventory	Part Number Part Description Effectivity Quantity On Hand Last E.O. Change Number Part Status
Resource Schedule	Resource Code Resource Description Resource Requirement Shop Order Operation Resource Requirement Load Factor Time Period

Figure IV-14

Shop Floor Management Subsystem

Output Summary

Subsystem Output	Frequency	Estimated Volume		Period Covered	Report Sequence	Distribution/Location
		Lines	Pages			
Dispatch Package	Daily as Released to Shop Floor	10,000	1,000	One Day	Shop Order Number/Operation Sequence	Operations Control USBI-KSC
Resource Requisitions	Daily as Released to Shop Floor	500	500	One Day	Resource Group/Resource Code	Operations Control USBI-KSC
Material Requisitions	Daily as Released to Shop Floor	12,800	1,000	One Day	Shop Order/Pick Sequence	Inventory Segregation Area USBI-KSC Operations Control USBI-KSC

Table IV-9

Shop Floor Management SubsystemKey Output Data Elements

<u>Subsystem Output</u>	<u>Key Data Element</u>
Dispatch Packages	Shop Order Number Part Number/Effectivity/ Serial Number Part Description Operations Code Operations Description Operations Start Time Operations Due Date WAD Cross-Reference Drawing Cross-Reference Work Center Information Labor Tickets Resource Information Picking List Cross-Reference Previous Operations Parallel Operations Succeeding Operations
Resource Requisitions	Resource Code Resource Description Shop Order Operations Code Operations Description Resource Delivery Time/Date Resource Time Required Resource Return Time/Date
Material Requisitions	Shop Order (parent part) Pick List Release Code Part/Effectivity/Status Serial Number Storage Location Quantity Part Find Cross-Reference Number on Parent Drawing

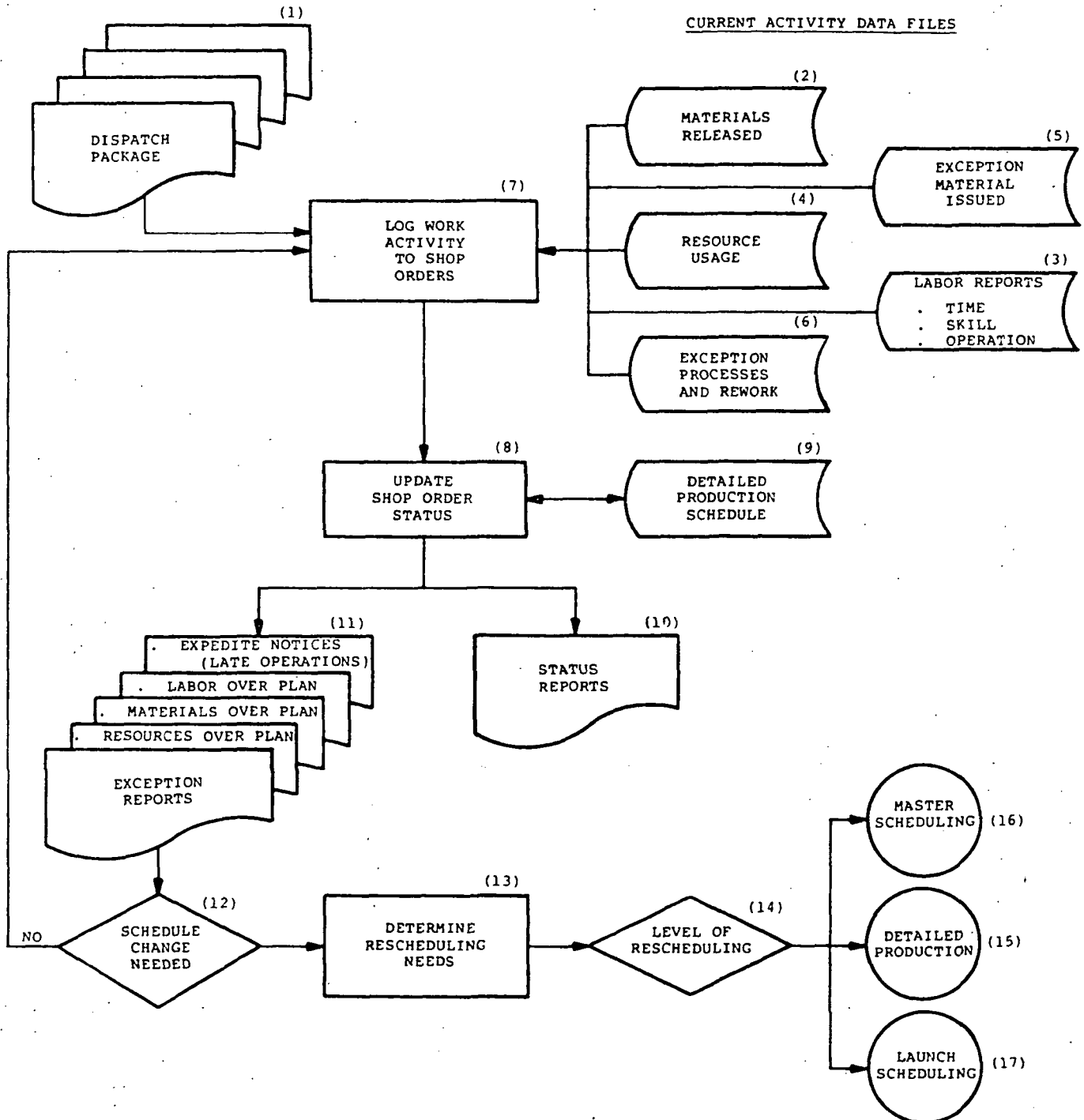
(e) Operations Control

The primary functions of the Operations Control Subsystem (Figure IV-15) are to track the resources expended to a shop order, including labor, material and parts, GSE and tools, etc., and to track the status of open shop orders.

1. Subsystem Narrative: A dispatch package (1) from the Shop Floor Management Subsystem is passed to this subsystem. All resources utilized, including materials (2) labor (3), and other resources (4), as well as exception materials issued (5) and exception processes and rework, are logged against the shop orders (7). This provides information to update shop order status (8) and to compare actual activity and resource usage to the production schedule (9).

There are two outputs of this comparison, shop order status reports (10) and exception reports (11). The exception reports provide management with summary information on resource usage variances, and overdue operations. If management does not see a need for schedule changes (12), the exception reports that have been issued are logged in as shop order work activity. If, however, it is determined that rescheduling is necessary (13), the degree of impact (14) on the detailed production schedule (15), the master schedule (16), and/or the launch schedule (17) need to be determined. Thus, rescheduling can range from a manual adjustment of shop floor priorities or a revision in the target dates in the automated production control system, depending on the needs seen by management.

Figure IV-15
Operations Control Subsystem



2. Key Input Source and Data Elements. Figure IV-16 shows a summary of the key inputs required for the Operations Control Subsystem. The "topical reference" refers to the major subsystem input indicated on the flow chart.

Table IV-10 indicates the key data elements associated with each of the inputs identified.

3. Key Output Definitions and Data Elements.

Figure IV-17 shows a summary of the key outputs provided by the Operations Control Subsystem. The "subsystem output" reference refers to either a report, CRT screen, file update, or a combination of the three.

Table IV-11 indicates the key data elements associated with the subsystem output.

Figure IV-16

Operations Control Subsystem

Input Summary

Topical Reference	Source of Data	Originator of Data/ Location	Estimated Frequency	Volume		Where Used
				Per Frequency	Annual	
Dispatch Packages	From Shop Floor Management Subsystem	Dispatching USBI-KSC	Daily	1,000 pages	To Be Determined	Operations Control USBI-KSC
Material Released	Inventory Transactions	Inventory Control USBI-KSC	Daily	12,800 records	To Be Determined	Performance Monitoring USBI-KSC
Exception Material Issued	Inventory Transactions	Inventory Control USBI-KSC	Daily	To Be determined	To Be Determined	Performance Monitoring USBI-KSC
Resource Usage	Resource Transactions	Operations Control USBI-KSC	Daily	500 records	To Be Determined	Performance Monitoring USBI-KSC
Labor Reports	Labor Transactions	Operations Control USBI-KSC	Daily	1500 direct workers 5 time cards Each 7500 Records	To Be Determined	Performance Monitoring USBI-KSC
Exception Processes and Rework	Shop Order Transactions	Process Engineering USBI-KSC	Daily	To Be Determined	To Be Determined	Performance Monitoring USBI-KSC

Table IV-10

Operations Control SubsystemKey Input Data

<u>Subsystem Input</u>	<u>Key Data Element</u>
Dispatch Packages	Shop Order Number Part Number/Effectivity/ Serial Number Part Description Operations Code Operations Description Operations Start Time Operations Due Date WAD Cross Reference Drawing Cross Reference Work Center Information Labor Tickets Resource Information Picking List Cross Reference Previous Operations Parallel Operations Succeeding Operations
Material Releases	Shop Order (parent part) Pick List Release Code Part/Effectivity/Status Serial Number Storage Location Quantity Part Find Cross Reference Number on Parent Drawing
Exception Material Issued	Shop Order (parent part) Pick List Release Code Part/Effectivity/Status Serial Number Storage Location Quantity Part Find Cross Reference Number on Parent Drawing
Resource Usage	Resource Code Resource Description Shop Order Operations Code Operations Description Resource Delivery Time/Date Resource Time Required Resource Return Time/Date
Labor Reports	Worker Clock Number Labor Skill certification Shop Order Operations Time Clocked on the Operation Time Clocked off the Operation
Exception Processes and Rework	Shop Order Code Operation Code Operation Description Operation Sequence Resource Delivery Time/Date Resource Time Required Resource Return Time/Date

Figure IV-17

Operations Control Subsystem

Output Summary

Subsystem Output	Frequency	Estimated Volume		Period Covered	Report Sequence	Distribution/Location
		Lines	Pages			
Updated Production Schedule	As required	500	10	Work-in-Process	Date/Shop Order or Operation	Production Control USBI-KSC Dispatching USBI-KSC Operations Control USBI-KSC Inventory Control USBI-KSC
Exception Reports	Daily	To Be Determined	To Be Determined	Work-in-Process	Shop Order/Operation or Work Center or Labor Skill or Part or Resource Code	Production Control USBI-KSC Dispatching USBI-KSC Operations Control USBI-KSC Inventory Control USBI-KSC
<ul style="list-style-type: none"> . Late OPNs . Labor . Material . Other Resources 						
Status Reports	As Required	500	10	Work-in-Process	Shop Order/Operation or Work Center/Shop Order/Operation	Production Control USBI-KSC Dispatching USBI-KSC Operations Control USBI-KSC Inventory Control USBI-KSC

Table IV-11Operations Control SubsystemKey Output Data Elements

<u>Subsystem Input</u>	<u>Key Data Element</u>
Updated Production Schedules	Shop Order Number Part Number/Effectivity/Serial Number Operation Code Operation Description Operation Start Date Operation Due Date Quantity
Exception Reports	
• Late Operation	Shop Order Number Part Number/Effectivity/Serial Number Operation Code Operation Description Operation Start Date Operation Due Date Quantity Actual Time Started Actual Time Completed Supervisor Notes
• Labor	Shop Order Number Part Number/Effectivity/Serial Number Operation Code Operation Description Operation Start Date Operation Due Date Quantity Labor Skill Certification Re- quirements Labor Skill Certification Standard time Labor Skill Certification Actual Time Supervisor Notes

Table IV-11Operations Control SubsystemKey Output Data Elements (Cont'd.)

<u>Subsystem Input</u>	<u>Key Data Element</u>
. Material	Shop Order Number Part Number/Effectivity/Serial Number Operation Code Operation Description Operation Start Date Operation Due Date Quantity Material Pick List Shorted Material Extra Materials Released
. Other Resources	Shop Order Number Part Number/Effectivity/Serial Number Operation Code Operation Description Operation Start Date Operation Due Date Quantity Resource Required Resource Time Required Resource Actual Time
Status Reports	Shop Order Number Part Number/Effectivity/Serial Number Operation Code Operation Description Operation Start Date Operation Due Date Quantity

(f) Performance Analysis

The Performance Analysis Subsystem (Figure IV-18) is designed to track performance on shop orders on a periodic basis or as requested by management. Some of the reports which are available to management include:

- Planned versus actual schedule performance.
- Planned versus actual labor performance.
- Planned versus actual work center performance.
- Planned versus actual costing performance.
- Planned versus actual operating budget performance.

1. Subsystem Narrative. Upon a request from management (1) for one or more specific performance reports (or on a periodic basis), the performance analysis subsystem requires the updated status of shop orders (2), shop order activity files (3), and the detailed, updated, production schedule (4). One of the mechanisms of the subsystem is to purge and summarize the activity files (5) to create more useful performance reports. This summarized information is then cycled back through the activity data files.

The comparison of planned performance to actual performance (6) produces a series of performance reports (7) on schedule, labor, work centers, cost and operating budgets.

2. Key Input Sources and Data Elements. Figure IV-19 shows a summary of the key inputs required for the Performance Analysis Subsystem. The "topical reference" refers to the major subsystem input indicated on the flowchart.

Figure IV-18

Performance Analysis Subsystem

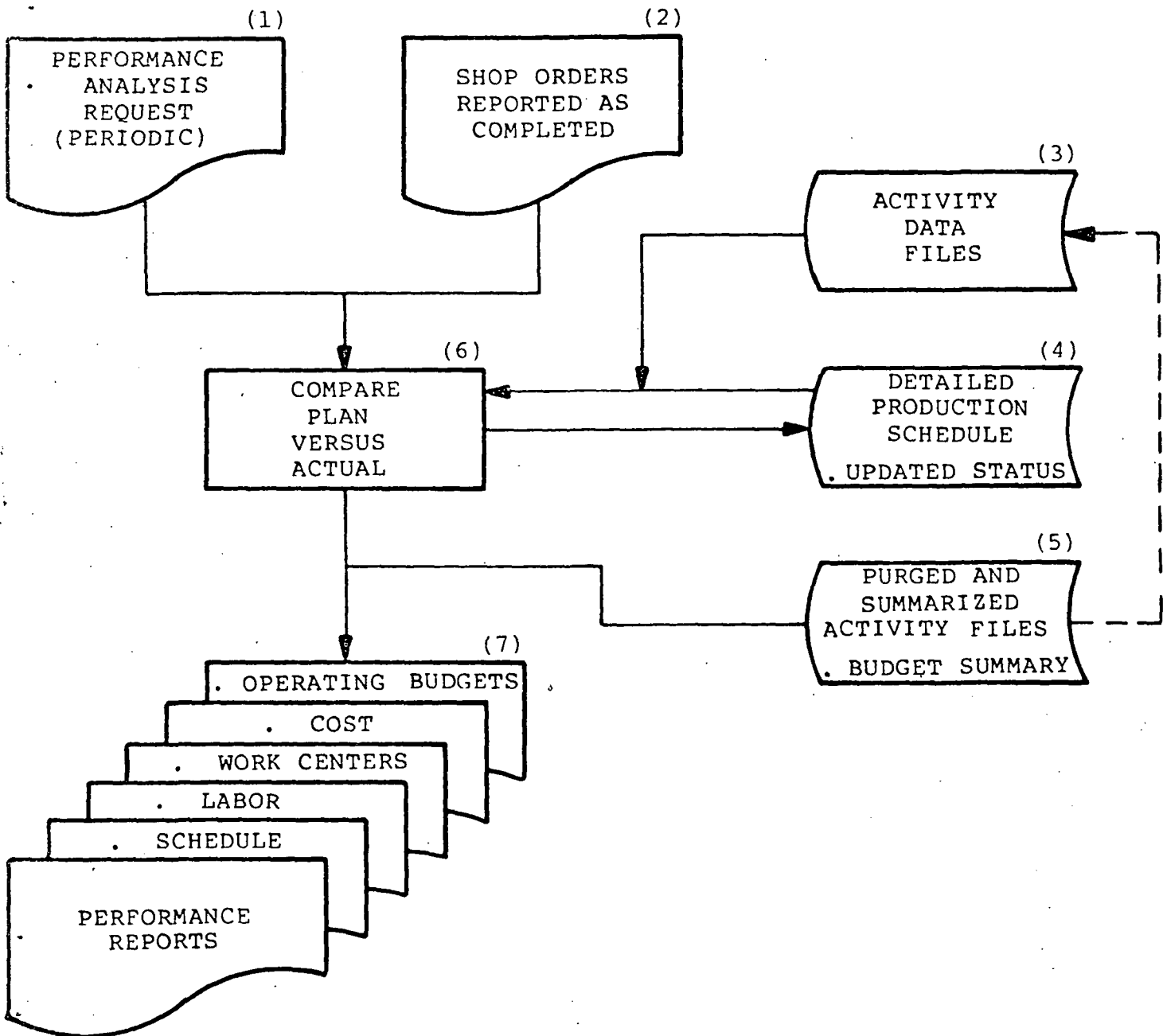


Table IV-12 indicates the key data elements associated with each of the inputs identified.

3. Key Output Definitions and Data Elements. Figure IV-20 shows summary of the key outputs provided by the Performance Analysis Subsystem. The "subsystem output" reference refers to either a report, CRT screen, file update or a combination of the three.

Table IV-13 indicates the key data elements associated with the subsystem output.

Figure IV-19

Performance Analysis Subsystem

Input Summary

<u>Topical Reference</u>	<u>Source of Data</u>	<u>Originator of Data/ Location</u>	<u>Estimated Frequency</u>	<u>Volume</u>		<u>Where Used</u>
				<u>per Frequency</u>	<u>Annual</u>	
Performance Request	Scheduled Report Run	Operations Budgeting USBI-KSC Performance Reporting USBI-KSC	Monthly/ Weekly/ On Demand	To Be Determined	To Be Determined	Performance Monitoring
Shop Orders Completed	File	Operations Control USBI-KSC	Daily	To Be Determined	To Be Determined	Performance Monitoring
Activity Data Files	File	Operations Control USBI-KSC	Daily	To Be Determined	To Be Determined	Performance Monitoring
Detailed Production Schedule	File	Dispatching and Operations Control USBI-KSC	Daily	To Be Determined	To Be Determined	Performance Monitoring

Table IV-12Performance Analysis SubsystemKey Input Data

<u>Subsystem Input</u>	<u>Key Data Element</u>
Performance Request	Request Code (Type) Report Date
Shop Orders Completed	Shop Order Number Operation Operation Time Log Exception Operations
Activity Data Files	Shop Order Number Operation Operation Time Log Work Center Number Work Center Standard Duration Time Work Center Actual Time Labor Certification Number Labor Certification Standard Time Labor Certification Actual Time Supplies Requisitioned Supplies Used Tools/GSE/Subcontractor Number Tools/GSE/Subcontractor Standard Duration Time Tools/GSE/Subcontractor Actual Time
Detailed Production Schedules	Shop Order Number Operations Completed Operations Time Log

Figure IV-20

Performance Analysis Subsystem

Output Summary

Subsystem Output	Frequency	Estimated Volume		Period Covered	Report Sequence	Distribution/Location
		Lines	Pages			
Schedule Performance	Weekly/ Monthly	To be Determined	To be Determined	Weekly/ Monthly	Period/Shop Order Shop Order/ Period	Resource Planning USBI-HSV Dispatching/Operations Control USBI-KSC
Labor Performance	Weekly/ Monthly	To be Determined	To be Determined	Weekly/ Monthly	Period/Labor Certification	Resource Planning USBI-HSV Dispatching/Operations Control USBI-KSC
Work Center Performance	Weekly/ Monthly	To be Determined	To be Determined	Weekly/ Monthly	Period/Work Center	Resource Planning USBI-HSV Dispatching/Operations Control USBI-KSC
Cost Performance	Weekly/ Monthly	To be Determined	To be Determined	Weekly/ Monthly	Period/Cost Category	Resource Planning USBI-HSV Dispatching/Operations Control USBI-KSC
Operating Budget Performance	Weekly/ Monthly	To be Determined	To be Determined	Weekly/ Monthly	Period	Resource Planning USBI-HSV Performance Monitoring USBI-KSC

Table IV-13Performance Analysis SubsystemKey Output Data Elements

<u>Subsystem Input</u>	<u>Key Data Element</u>
Schedule Performance	Date Shop Order Operation Number Operation Scheduled Start Operation Actual Start Operation Scheduled Due Date Operation Actual Due Date
Labor Performance	Date Shop Order Number Operation Number Labor Certification Code Labor Certification Standard Time Labor Certification Actual Time
Work Center Performance	Date Shop Order Number Operation Number Work Center Code Work Center Standard Duration Time Work Center Actual Duration Time
Cost Performance	Date Shop Order Number Operation Number Resource Code Resource Standard Cost Resource Actual Cost
Operating Budget Performance	Period Budget Element Budget Element Description Budget Element Budgeted Cost Budget Element Actual Cost Budget Element Variance

SRB/APC INFORMATION FLOW

The SRB production control system information flow is shown in Figure IV-21. It is described in the paragraphs below.

(a) Launch
Schedule

The launch schedule is the primary criteria for production planning and scheduling. Refurbishment scheduling uses the planned recovery schedules based on the launch schedule. Resource planning uses the information from the launch rate, launch dates, and the refurbishment schedule to plan resource requirements.

An objective of the SRB/APC system is to provide management with needed information with sufficient lead time to make decisions which ensure mission compliance.

(b) Design
Engineering

The design engineering function (sustaining engineering) is responsible for the creation of and/or changes to:

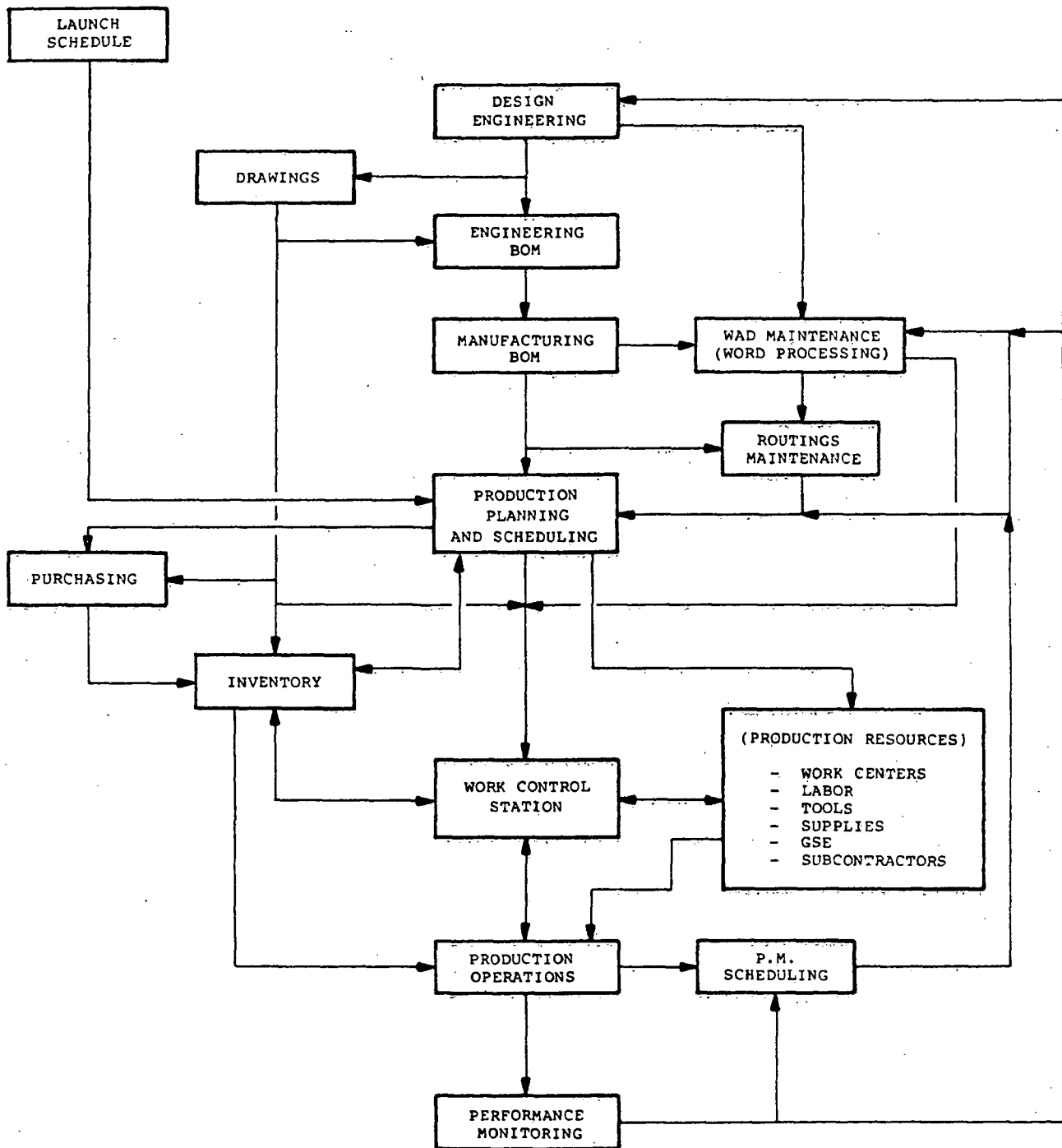
1. Drawings.
2. Engineering bills of material.
3. Part master.

The impetus for design engineering changes and, therefore, information flows, will come from:

1. Analyses of operations performance and exceptions.
2. Industrial engineering requests.
3. Flightworthiness improvement programs.

Figure IV-21

SRP/APC Information Flow



4. SRB and component useful life improvement programs.
5. Weight reduction programs.
6. Cost reduction programs.
7. Purchasing and vendor requests.

Design engineering information and the manufacturing BOM will be used to trigger creation of, or changes to, WADs.

(c) Drawings

The drawings are the graphic representations (cartoons) of the physical part or assembly. Drawings will be developed for each item to be inventoried, and will be communicated from design engineering to the engineering bill of materials.

Drawings are used for the following purposes.

1. Communications with vendors regarding part dimensions and specifications.
2. Definition of part effectivity changes.
3. Graphic representation of engineering BOM component installation location.
4. Production operations support information. The drawings would be included in the job packet.

(d) Engineering BOM

The engineering BOM is a structured parts list (generation breakdown). This list will identify each level of assembly and the components of that level. For example, the SRB flight

set would be one level, an SRB another level, and the aft skirt another level.

Engineering changes to drawings or part specifications would require changes to the engineering BOM, thus requiring an information flow.

(e) Manufacturing
BOM

The manufacturing BOM is a revised structured parts list based on the engineering BOM. This restructuring is required to coordinate the materials flow to the production operations flow.

This restructuring will include creation of new levels to the BOM, or exclusion of some engineering BOM levels from the manufacturing BOM.

The manufacturing BOM is the primary data source for the time-phased material requirements explosion of the production master schedule, and therefore must be communicated to production planning and scheduling.

WAD and routing maintenance will use these manufacturing BOMs as reference materials. Each level of the BOM will require a routing. Each operation of a routing will require a WAD or a section of a WAD.

Parts lists previously included in the WAD could also now be maintained in the manufacturing BOM. A time-phased release of

parts in multiple pick lists will be coordinated by a release off-set lead time.

(f) WAD Maintenance

Work authorization document (WAD) maintenance is the maintaining of current production process instructions. These documents are detailed narrative descriptions of every work step required to perform a task.

Design engineering changes or production process changes will require WAD rewrites or modifications. The volume of narrative is not needed for production control purposes, but hard copy WADs are needed on the shop floor to provide instructions to labor and to record quality inspection "buy-offs". As a result of these needs for these voluminous documents and as a consequence of frequent design or process engineering changes, it appears to be most practical to maintain WADs on some type of word processing equipment.

WADs relating to the assembly of one level in the manufacturing BOM are grouped into a routing network. Each WAD, or WAD section, is summarized in a routing operation.

Hard copies of the WADs about to be released to the shop floor are maintained in the work control station.

(g) Routing Maintenance

Routing maintenance is the organization of production operations needed to complete an assembly and includes the

the identification of resources required to perform each operation. Production operations will be organized into a network of parallel and series work activities.

Resources required by an operation will include:

1. Work centers.
2. Labor by skill certifications.
3. Supplies.
4. Tools.
5. GSE.
6. Subcontractor support.
7. Alternate resources.

Routings may be adjusted because of WAD or manufacturing BOM charges. In addition, a routing operations sequence may be changed based on feedback from production operations or industrial engineering.

Routings are the primary data source for loading and scheduling production resources. The time required at a work center and the labor skills needed are scheduling constraints. The scheduling of a shop order routing is adjusted to ensure that scheduled work does not exceed the available capacities of constrained resources.

(h) Production
Planning and
Scheduling

Production planning and scheduling is the core of the production control system. This activity includes:

1. Master scheduling.
2. Materials requirements planning.
3. Capacity requirements planning.
4. Shop floor dispatching.

Master scheduling takes the launch schedule and translates it into a production schedule of new and refurbished major assemblies. This subsystem module then validates that the production resources required to meet the production schedule will be available.

Materials requirements planning explodes the master schedule into time-phased detailed materials requirements.

Capacity requirements planning explodes the materials requirements schedule of production shop orders into detailed time-phased resource requirements, including work center, labor, tools, supplies, GSE and subcontractors.

Shop floor dispatching assigns available resources to each production shop order and schedules the release of each shop order. Shop orders are released to the shop floor through a production work control station.

The production and scheduling activity also incorporates the various feedback loops in the system, and is therefore driven by production operations and preventive maintenance scheduling, performance monitoring and resource availability.

(i) Purchasing

Purchasing receives purchase requisition information from materials requirements planning. These requisitions are satisfied by placement of vendor purchase orders. Drawings and part specifications would accompany purchase orders when they are placed.

Purchase orders and due dates would be recorded as a planned inventory receipt of materials.

(j) Inventory

Inventory is the central coordination point for SRB/APC operations information. Each launch date, dictated by the launch schedule, is a requirement for an inventory control item; i.e., an SRB flight set. The shop order to stack this flight set is a "replenishment order" which satisfies a launch date, but requires major assemblies. Major assembly shop orders satisfy major assembly requirements and so on down to material requirements, which are satisfied by purchase orders or on-hand inventory.

The materials flow is coordinated through the inventory system, and scheduled by exploding the manufacturing BOM.

Inventory receipts recording data are accomplished with purchase and shop order receiving documents. The purchase order receiving documents would be released to receiving in hard copy form as a receipt arrives. These receiving documents, which may include part identification tags, then are sent with the materials to inspection. The receiving personnel would enter receiving information into a CRT. This information would include purchased items received per planned receipt, date received and by whom, serial number information, and the location of the items (e.g., inspection). This automated record of receipts would be used by purchasing to verify vendor invoices.

Inspection would receive a hard copy of the receiving document plus the part "data pack" from the vendor. Inspection would verify part flightworthiness, or determine rework needed to make the part flightworthy. A rework shop order would assign a rework status to the part; e.g., hold for rework, rework immediately, return to vendor, etc. Later allocation of that part to a requirement would schedule the rework shop order to be due when the part is required. Inspection would also review the vendor data pack and enter relevant information into the part "as built" configuration information file.

The shop order receiving documents will be included in the job packet. This would be an input document used to signal the completion of a shop order, and the location to which it was moved. This location could be an inventory segregation area or

another work center if the shop order routing provides that instruction.

Inventory disbursements recording data are accomplished with picking lists. Picking lists of materials required by a shop order are controlled by the manufacturing BOM. When a shop order is to be released to the production floor the time-phased release of materials associated with the shop order creates a series of pick lists. These pick lists are used to disburse parts to production as required.

Dispatching and the work control station activities will pre-verify that the inventory is on hand to satisfy each picking list. Shortages, or potential shortages, will be expedited two to four weeks in advance. Picking lists on which a part is shorted can be released by a manual authorization, and the shorted part would then be expedited and a shorted parts picking list created.

Pick lists would accompany the parts to the shop floor, where parts and part serial numbers received would be rechecked against the pick list and acceptance would be indicated on the list. The signed-off pick list would then be turned in to the work control station to become part of the "as built" hard copy backup.

Pick lists would be printed in advance of picking to provide a capability to manually control picking activities needed for shop floor activities. This manual control capability is

necessary to provide backup in case the SRB/APC system "goes down".

Production planning and scheduling activities, purchasing activities and shop floor activities will shift planned receipts and disbursement schedules. Therefore, the documentation needed to support receiving and disbursement will not be created until needed. However, the information would be available through on-line terminals, when requested.

(k) Work Control
Stations

Work control stations are the major shop floor data collection and information distribution and control points. The activities performed in these stations will support shop floor supervisors by supplying information needed to coordinate "people, parts, and paper" (or information in a paperless environment) and will support the SRB/APC information update needs by recording data from the shop floor.

These work control stations will be located on the production shop floor, close to the work being performed. These work control stations would function similarly to the current "TAIR" stations.

The work control station activity priorities will differ based on the type of work being performed. For example, work control station activities include WAD issuance, as built configuration data collection, resource assignments, etc.,

while the major activities of the work control stations are:

1. Assembly of job packet information.
2. Prerelease verification of resource availability and resource assignment to each shop order.
3. Monitoring and control of shop floor operations.
4. Gathering of data to support SRB/APC system needs and to provide configuration backup in hard copy, as well as input to other systems such as ACMS, ADRS, etc.

The critical nature of work control activities makes it necessary to have job packets and resources verified early enough to provide manual backup in case the SRB/APC system "goes down".

(1) Production Resources

Production resources are the resources needed to perform work. Production planning and scheduling will provide work scheduling capacity loading or requirements for these resources.

Work scheduling will be performed for each work center. Production shop order operations will be queued at each work center based on the shop order priority.

Capacity loading will be performed for work centers, and labor certification. The time period (weekly) requirements will be compared against the resource capacity available. Requirements will be specified for tools, supplies, GSE and subcontractors.

Work control stations will reverify the assignment or commitment of resources to a shop order, then release requisitions to acquire these resources.

(m) Production
Operations

Production operations is where work is performed. This activity is also responsible for reporting progress and exceptions.

Production operations supervisors receive job packet information from the work control station. Inventory, and production resources would be scheduled to be delivered to the appropriate work center as work begins. This scheduling would be coordinated by the work control station, but work center selection of operations from the queue would be directed by the production supervisor.

The production supervisor's performance will be monitored against the operations queue priorities. Special circumstances may require that the supervisor select other than top priority operations. The system will identify most of these exceptions. For example, some exceptions might be:

1. Material kits not picked.
2. Resources schedule delivery conflicts which may cause adjustments to work center operations priorities.
3. Certified labor not available.
4. Need to expedite work for work centers of subsequent operations. (This should adjust the shop order priorities.)

Actual work performed will be tracked through data capture of operations progress, resource usage, and production exceptions. This information is reported back to the work control station which updates the SRB/APC system.

PM scheduling will also use exception information, as well as GSE usage history, to plan maintenance.

(n) PM Scheduling

PM scheduling plans maintenance based on GSE usage, maintenance logs and production exceptions. These scheduled PM shop orders must be supported by WADs and routings.

PM orders use the same work centers and labor skill certifications as production shop orders. Therefore, capacity loading and work scheduling will be performed by the same production planning and scheduling activity.

(o) Performance Monitoring

Performance monitoring will report the following:

1. Shop order schedule compliance.
2. Shop order labor skill certification productivity.
3. Shop order work center utilization.
4. Configuration deltas.
5. Shop order exceptions.
6. Period schedule compliance.
7. Period labor productivity.
8. Period work center utilization.

9. Subcontractor schedule compliance.
10. GSE schedule compliance.
11. Materials shorted.
12. Cost variance analysis.
13. GSE history report.

These performance reports will provide feedback to design engineering and process engineering, so that potential improvements can be analyzed. In addition, these reports may trigger PM work to be scheduled.

SRB PRODUCTION OPERATIONS
FLOW EFFECTS ON WORK
CONTROL STATIONS

The work control station emphasis changes based on the types of work being performed. The following sections will describe SRB/APC activities performed within each type of work. The SRB production operations flow is illustrated in Figure IV-22 on the following page.

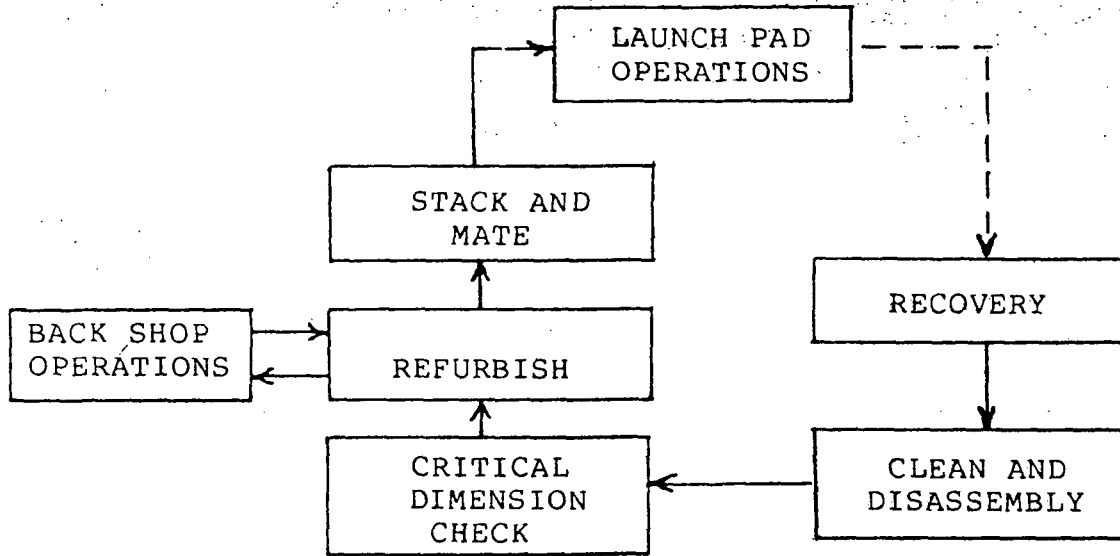
(a) Recovery
Operations

The work control stations for recovery operations have four major functions:

1. To assemble recovery order job packet.
2. To record changes to the recovery due dates.
3. To record recovery loss of an SRB.
4. To record actual time and labor against an operation.

Figure IV-22

SRB Production Operations Flow



(b) Clean and
Disassemble
Operations

The work control stations for clean and disassemble operations have the major objective of meeting a delivery schedule to provide spent refurbishable major assemblies.

The work performed may be less critical than refurbishment, and the labor skills may be more flexible; therefore, less control of these resources may be needed.

The work control stations' major functions are:

1. To assemble clean and disassemble order job packets.
2. To schedule capacity of critical work centers.
3. To record changes to the spent assemblies due dates.
4. To record exceptional damage status for non-refurbishable major assemblies.
5. To record actual time and labor against an operation.

(c) Critical
Dimension Check

The work control stations for Critical Dimension Check operations have the major objective of recording Dimension Check results which will determine materials needed and production resources needed to perform refurbishment.

The work performed may not require materials but does require special work centers, labor skill certifications and testing equipment. Therefore, control is centered on work centers, labor and tools.

The work control stations' major functions are:

1. To assemble testing order job packet information.
2. To schedule capacity of work centers (including hot fire).
3. To schedule capacity of labor skill certifications.
4. To schedule tool requirements.
5. To record results of activities performed.
 - (a) Components to be replaced.
 - (b) Component test results.
 - (c) Probable component disposition.
6. To record changes to due dates.
7. To record actual time and labor against an operation.

(d) Refurbishment and
Buildup Operations

The work control stations for refurbishment and buildup operations have two major objectives. These are to meet aisle transfer schedules and to manage the utilization of scarce resources.

The work to be performed uses critical work centers, labor skill certifications, tools, GSE and subcontractors.

Work centers must be scheduled by operations priorities to maximize work center utilization, and to achieve shop order due date targets.

Labor skill certification must be scheduled by operations priorities to maximize labor productivity and utilization (time on standard measured work).

Tools, GSE and subcontractors must be supplied to scheduled operations. The commitment schedules of shared GSE and subcontractors may change schedule operation priorities for preceding operations of the same shop order.

The work control stations' major functions for this type of work are:

1. To assemble refurbishment and buildup order job packets.
2. To schedule capacity of work centers.
3. To record shop order priority changes.
4. To provide current shop order priority and status and to provide resource status information to shop floor supervisors.
5. To record shop floor activity information.
 - (a) Work center start time.
 - (b) Work center stop time.
 - (c) Work center substitutions.
 - (d) Worker labor certification actual clock time on an operation.
 - (e) GSE and subcontractor time, logged by operation.

6. To provide shop floor supervisors with the following information:

- (a) Work center utilization.
- (b) Labor productivity.
- (c) Shop order schedule compliance.

(e) Back Shop
Operations

The work control stations for back shop operations have the major objective of creating or reworking components (LRUs) to flightready status, as required by refurbishment or buildup shop orders. This may also include effectivity upgrades, rework requested by inspection, rework requested by life management, and spent component rework.

The work performed requires materials, labor, and work priority management. The materials for rework will not always be known until rework is in process. Labor loads will also be difficult to plan for each order because the amount of rework required is difficult to project. Work priorities will primarily be set based on part due date commitment to a refurbishment or buildup shop order. Some back shop orders may be upgraded to inventory stock, and may have a low priority.

The work control stations' major functions are:

1. To assemble back shop order job packets.
2. To record shop order priority changes.

3. To provide current shop order priority and status changes to shop floor supervisors.

4. To input rework inventory requisitions to be communicated to the inventory segregation area.

5. To alert shop floor supervisors and dispatchers to potential work center or labor skill capacity problems.

(f) Stack and Mate
Operations

The work control stations for stack and mate operations have two major objectives. These are to meet work schedules which are dictated by launch schedules and to manage the utilization of scarce resources.

The work performed uses critical work centers, labor skill certifications (including inspection certifications), tools, GSE and subcontractors.

The scheduling difficulty of shop order operations is compounded by resource availability, hazardous operations, and integration with other contractors.

The work control stations' major functions are:

1. To assemble stack and mate order job packets.
2. To schedule capacity of work centers.
3. To record shop order priority changes.
4. To coordinate resource assignments and shop order operations priorities.

5. To provide current shop order priority and status to shop floor supervisors.

6. To record shop floor activity information.

7. To provide shop floor supervisors with performance information.

(g) Launch Pad
Operations

The work control stations for launch pad operations have the major objective of coordinating work and resources with contractor integration requirements.

The criticality of time available to perform an operation mandates that resources be ready prior to start of that operation.

The work control stations' major functions are:

1. To assemble launch pad order job packets.

2. To ensure on-site arrival of all required resources at the time needed.

3. To provide current shop order priority and status changes to shop floor supervisors and dispatchers.

4. To coordinate schedule changes with contractor integration management.

V - COMPUTER SYSTEM DESCRIPTION

INTRODUCTION

In this section, Kearney's recommendations for the APC Computer System are presented. Hardware requirements are defined in Section VIII.

Section V is organized as follows:

- Computer System Rationale - A discussion of key issues considered in the computer system design.
- High Level System Design - The proposed design is presented in flowcharts and narrative.
- File Definitions - The files identified in the high-level design are described.
- Evaluation of Existing NASA Systems - Eighteen existing or proposed NASA systems are reviewed for their applicability to the APC.
- Conceptual Integration - A discussion of the conceived integration or interface of ten NASA systems with the APC.

COMPUTER SYSTEM RATIONALE

1. Centralized versus Distributed. The two major locations with processing requirements are Huntsville (HSV) and Kennedy Space Center (KSC). The ideal processing solution would be to distribute the processing capacity (i.e., computer configurations) and information capacity (i.e., data files) to the location with primary responsibility for each activity associated with the

automated production control system.

For example, USBI/KSC could utilize its own computer to process activities that primarily occur there (e.g., inventory control, detailed capacity requirements planning, shop floor reporting) and USBI/HSV could utilize its own computer to process the activities that primarily occur there (e.g., master scheduling, material requirements planning, purchasing, maintenance to the manufacturing bills of material).

This approach would call for a distributed data base capability to allow a singular automated production control system to process data independent of file location. The potential benefits of this approach would include reduced communication costs, smaller computers in each location which could provide reflective backup capabilities, and reduced risk of total data base failure.

However, some of the difficulties posed by this approach include data base concurrency control, security, administration, and recovery. The risks associated with these problems would have to be weighed carefully against the potential benefits before making the design decision.

The vendors offering manufacturing resource planning software were each queried as to their capability to process in a distributed data base environment. No vendor indicated that they could. Thus to our knowledge, there is no existing software on the marketplace which would support such a concept. Indeed, distributive data base processing is a relatively new art and much

progress remains to be made before it is through its pioneering stage.

Consequently, the approach recommended by Kearney utilizes a centralized data base. This greatly facilitates control, administration, security, and recovery of the data base.

The added communications cost is not significant since the recommended location of the hardware is at KSC, where the majority of processing occurs. The data base will be distributed over multiple disk units to reduce the risks of total failure. Backup hardware is provided to reduce the risks of processing failure.

2. Interactive versus Distributed Processing. The recommended hardware architecture calls for interactive processing from all distributed peripherals. It is recognized that there is an opportunity to distribute some of the processing to peripherals supported on-line by minicomputers or intelligent controllers. This may be appropriate with the inventory control and shop floor reporting subsystems. Primary transactions (e.g., issues, receipts, labor reporting) could be collected interactively on minicomputers and batched on a daily basis to the central computer(s). This would relieve some of the communications load and central computer processing requirements. The risk of processing interruptions would be transferred from the potential failure of the communications network/central computer to the distributed minicomputers. This could potentially reduce the risks of processing downtime.

The trade-offs to this approach are that it would call

for customized programming at the minicomputer level, and increase the problems of data control, backup, and security.

The recommended approach utilizes the design philosophy of existing large-scale manufacturing resources planning software packages, and offers the greatest control over data transactions and communications. The question of whether it may be more advantageous to distribute some portions of the system data entry can be more concisely answered during the detail technical design phase of the project.

3. Location of Central Computing Site. The recommended location of the central computing site is Kennedy Space Center for three primary reasons:

- (a) Approximately 85% of the distributed peripherals are located in Kennedy Space Center.
- (b) There do not appear to be major requirements to interface with NASA/MSFC systems after the SRB design responsibility is transferred to USBI (estimated to be 1983).
- (c) There could be significant requirements to interface with KSC systems (e.g., KDMS, AUTOGOSS, Sims II) in the years 1983 and beyond.

4. Backup/Contingency Provisions. The hardware architecture, described in Section VIII, depicts backup disk storage and access, tape storage and access, central processors and main memory, printers, and communication controllers. This approach is designed to minimize the risk of the failure of any critical centralized hardware component that would cause system failure.

The distributed hardware (i.e., communication controllers, video display units, and printers) are user replaceable in the field, should hardware failure occur there and not be restorable in an adequate time frame. It is recommended that a safety stock (one or two each) of these equipment types be maintained in the event of equipment failure.

The following section also defines levels of file backup requirements according to the critical nature of the files. The levels are defined as follows:

- (a) High: Requires continuous audit trail transaction register, stored off-site on daily basis. Requires copy of complete file made on weekly basis and stored off-site.

Objective: File recovery within four hours if needed.

- (b) Medium: Requires continuous audit trail register, stored off-site on weekly basis. Requires copy of complete file made on semimonthly basis and stored off-site.

Objective: File recovery within eight hours if needed.

- (c) Low: Requires continuous audit trail register, stored off-site on weekly basis. Requires copy of complete file made on monthly basis and stored off-site.

Objective: File recovery within 24 hours if needed.

Levels of backup requirements and specific plans to accommodate these needs should be reviewed and refined during the detail design phase.

5. Physical Security Requirements. The hardware must

be physically protected from illegal access. Requirements for the central computer site should include:

- (a) Guards monitoring installation accesses.
- (b) All personnel required to wear badges.
- (c) Sign-in and sign-out logs.
- (d) Man-traps (i.e., dual doors for singular access).
- (e) Electronic video observation equipment.

Security requirements for off-site storage need only include items (b) through (d).

6. Access Security Requirements. Access security requirements for the data base files which are discussed in the following section are defined below:

- (a) Critical: Requires terminal key, authorized terminal identifier, log-on password and data base password for read access. Requires two data base passwords for write access. Produces logging trail of access which must be reviewed by USBI security officer.
- (b) High: Requires terminal key, log-on password and data base password for read/write capability.
- (c) Medium: Requires terminal key, and log-on password for read capability. Requires data base password for write capability.

7. Contingency Requirements. It is not recommended that detailed backup manual methods be developed for SRB automated production control contingency requirements. These contingencies

should be accommodated by processing key activities (e.g., printing material requisitions, routings) at least eight hours in advance of need.

The hardware manufacturer service levels should be established for on-site call within two hours of system failure.

8. Existing NASA Processing Capacity. The processing requirements of the APC system were reviewed against existing capacity at KSC, NASA/MSFC, and Slidell. None of these locations has or can make available adequate processing requirements to accommodate the APC requirements.

HIGH LEVEL SYSTEM DESIGN

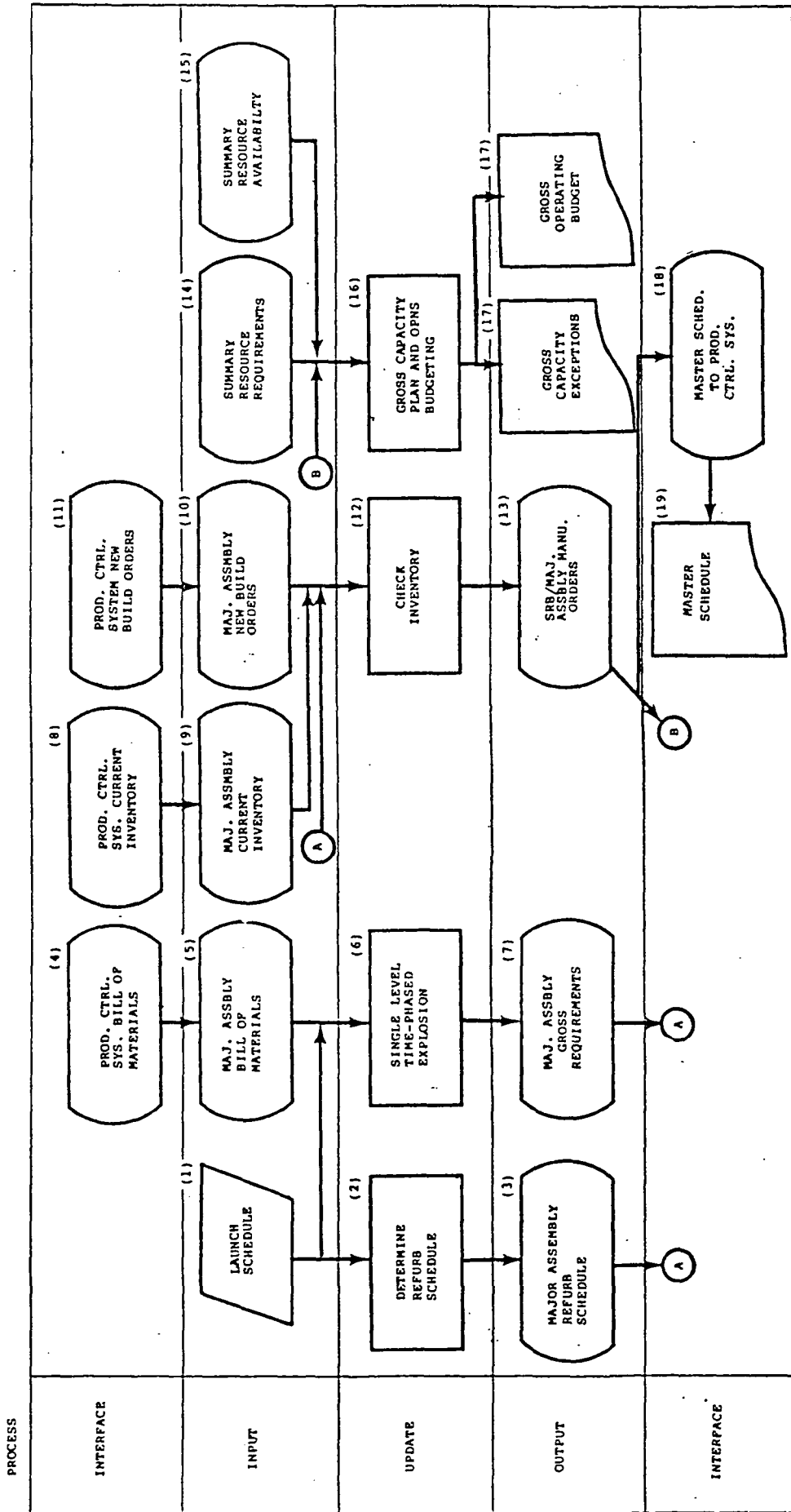
In this section, a flowchart and accompanying narrative depicts system interfaces, inputs, updates and outputs for each of the following mainstream subsystems:

- Master Scheduling Subsystem.
- Material Requirements Planning Subsystem.
- Capacity Requirements Planning Subsystem.
- Shop Floor Management Subsystem.
- Operations Control Subsystem.
- Performance Analysis Subsystem.

(a) Master
Scheduling
Subsystem

The master scheduling subsystem is depicted in Figure V-1. The launch schedule (1) is input into the system via CRT or punched cards. This file is used to determine and anticipate scheduled receipts of major assembly refurbished units by applying the standard lead times to refurbish each unit (2), and creates a file with this data in it (3). The automated production control system provides the bill of materials (4) from which the major assembly bill of materials file is extracted (5). The launch schedule is exploded by using the major assembly bill of materials to meet the launch schedule (6). These are known as the major assembly gross requirements and are stored in a working file (7). The current inventory status of major assemblies (9) is extracted from the automated production control system inventory status file (8). A file of scheduled receipts of new build major assemblies (10) is extracted from the automated production control system new build orders file (11). The availability of inventory to meet the major assembly gross requirements over a time-phased schedule is checked (12), by comparing the time-phased gross requirements (7) with the inventory status of major assemblies (9), scheduled receipts of new build major assemblies (10), and scheduled receipts of refurbished major assemblies (3). The SRB major assembly manufacturing order file (13) is created, reflecting the orders to build new and/or refurbished major assemblies to meet the launch schedule. This file is processed with the summary

Figure V-1
 Automated Production Control System
 Master Scheduling Subsystem



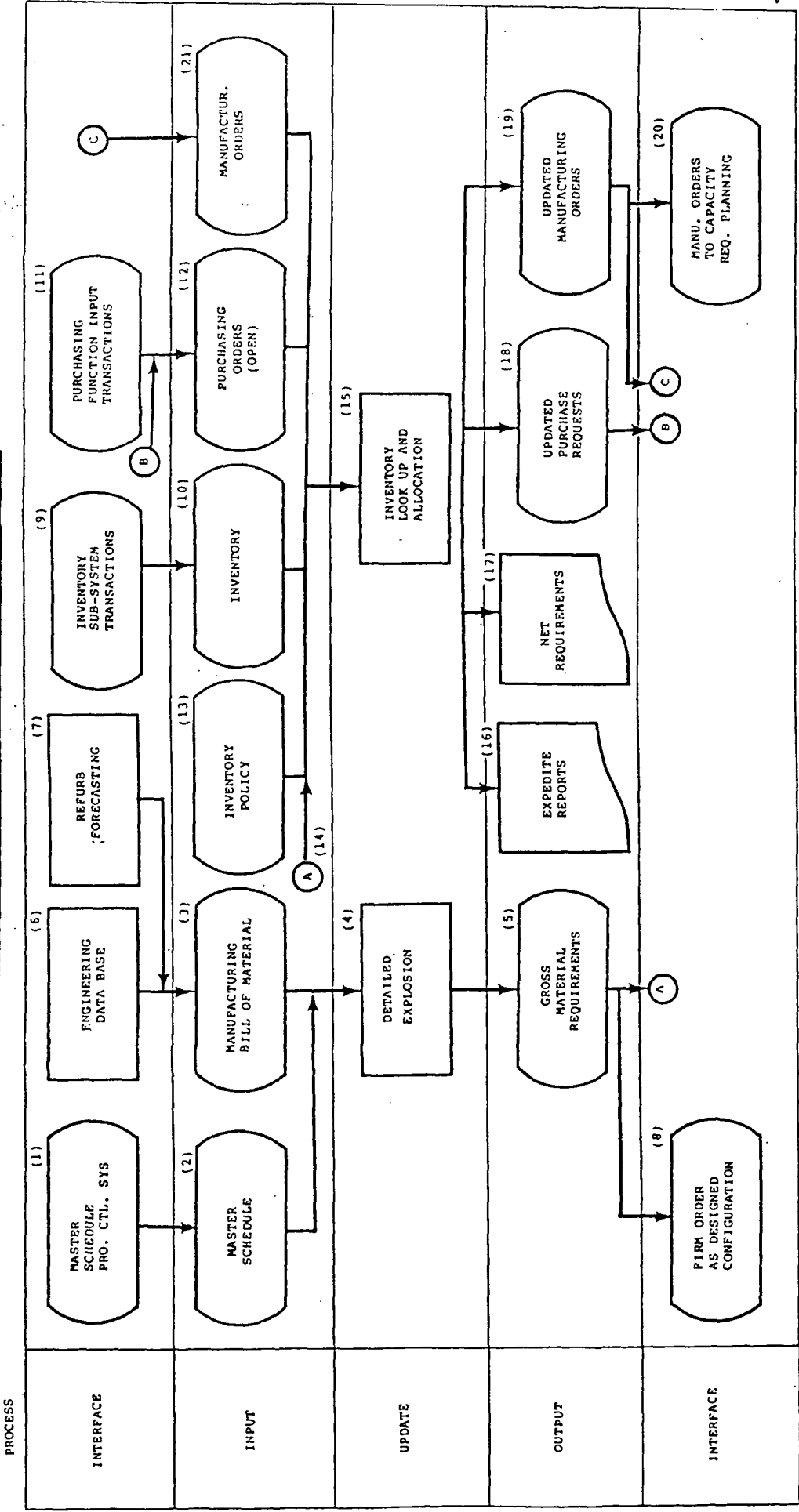
resource requirements file (14) and the summary resource availability file (15) to determine the gross capacity plan and gross operating budgets (16) which are produced as reports (17). Based on acceptability of the gross operating budget and gross capacity plan, the solid rocket booster major assembly manufacturing orders file (13) is passed to the material requirements planning subsystem of the automated production control system, as the master schedule (18). This master schedule is also available as a computer printout (19).

(b) Material
Requirements
Planning
Subsystem

The master schedule (1), produced in the master scheduling subsystem, is input into the material requirements planning subsystem (2), depicted in Figure V-2. The master schedule is processed with the manufacturing bill of materials file (3), to produce a detailed explosion (4), which identifies all of the gross material requirements necessary to build the major assemblies and SRB (5). The manufacturing bill of material file is maintained with the engineering data base and pending effectivities for new parts/components (6), and the refurbishment forecasted bill of materials estimates (7). The gross material requirements file (5) also becomes (by firm order) the "as designed" configuration for each launch (8). This file will be used later to produce the "delta" report between the "as designed" configuration and the "as built" configuration. The inventory module (9) transactions provide for a current

Figure V-2

Automated Production Control System
Material Requirements Planning Subsystem



inventory status file for all parts associated with the solid rocket booster (10). The purchasing function (11) transactions create an open purchase order file (12) which reflects the scheduled receipts of parts. An inventory file (13) is maintained of inventory policies which may dictate stock levels (e.g., safety stock). The gross material requirement file is then processed (14) with the inventory policy file, the inventory status file, the open purchase order file, and existing manufacturing orders of work-in-process (21) and an inventory look-up and allocation is performed (15) to determine the current availability or scheduled availability of parts to meet the gross material requirements. As a result of this process, expedite reports may be generated (16) to expedite the scheduled receipts of parts on current open purchase orders. A report showing net requirements (i.e., part requirements beyond current on-hand and scheduled receipts to meet the gross material requirements) (17) is produced. Requests for purchase orders (18) are produced to acquire the necessary parts which are bought to meet the net requirements. Existing manufacturing orders are updated and new manufacturing orders are created to build all of the various components and assemblies of the SRB to meet the launch schedule (19). This file becomes the manufacturing orders file (20) which is passed to the capacity requirements planning subsystem.

(c) Capacity
Requirements
Planning
Subsystem

The manufacturing orders produced in the material requirements planning subsystem (1) are input to the capacity requirements planning subsystem (Figure V-3) as manufacturing orders (2). These manufacturing orders are then translated into detailed shop orders (3) by processing the manufacturing orders file with the routings file (4). The routings file is maintained with the work authorization document module (5). The output of this process is a file of time-phased shop orders (6). This file is then merged with preventive maintenance requirements file (7) which is created and maintained by preventive maintenance transactions (8), the exception process documents file (9) which is maintained by the automated production control shop floor operations subsystem (10), and the process constraints file (11). The detailed scheduling process is then performed (12) to schedule not only the time-phased shop orders but also preventive maintenance and exception processing requirements within the limits of process constraints. This produces the detail scheduled shop orders file (13). These detailed scheduled shop orders (14) are then processed with the work center capacities file (15) and the resource and skill capacities (16) and a load summarization (17) process is performed producing several outputs. The labor skill loads are reported (18); as are the resource requirements (19). The work center capacity load and rescheduling recommendations (20) report is produced and utilized by the capacity planners to determine the extent of rescheduling

Figure V-3
(Page 1 of 2)

Automated Production Control System

Capacity Requirements Planning Subsystem

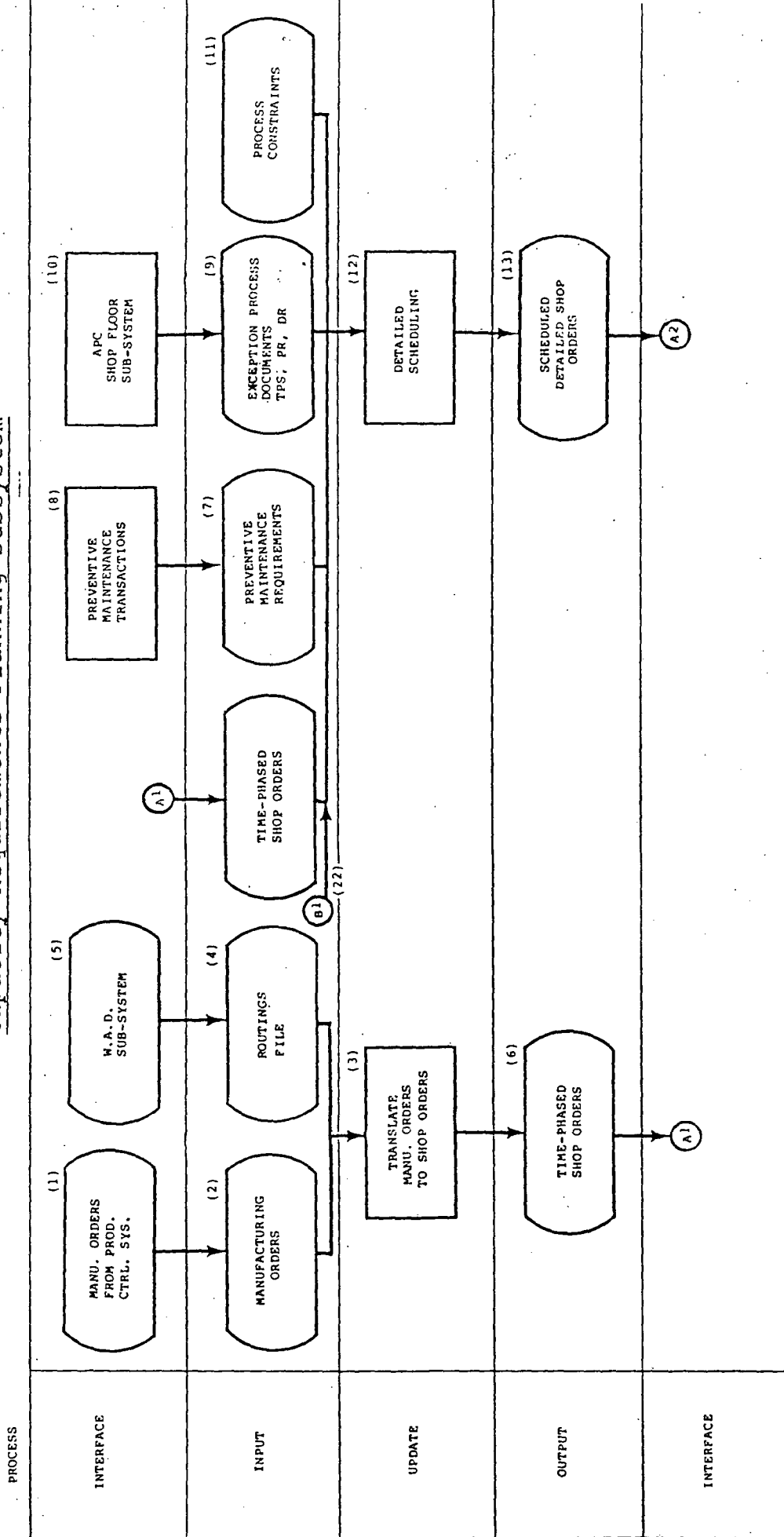
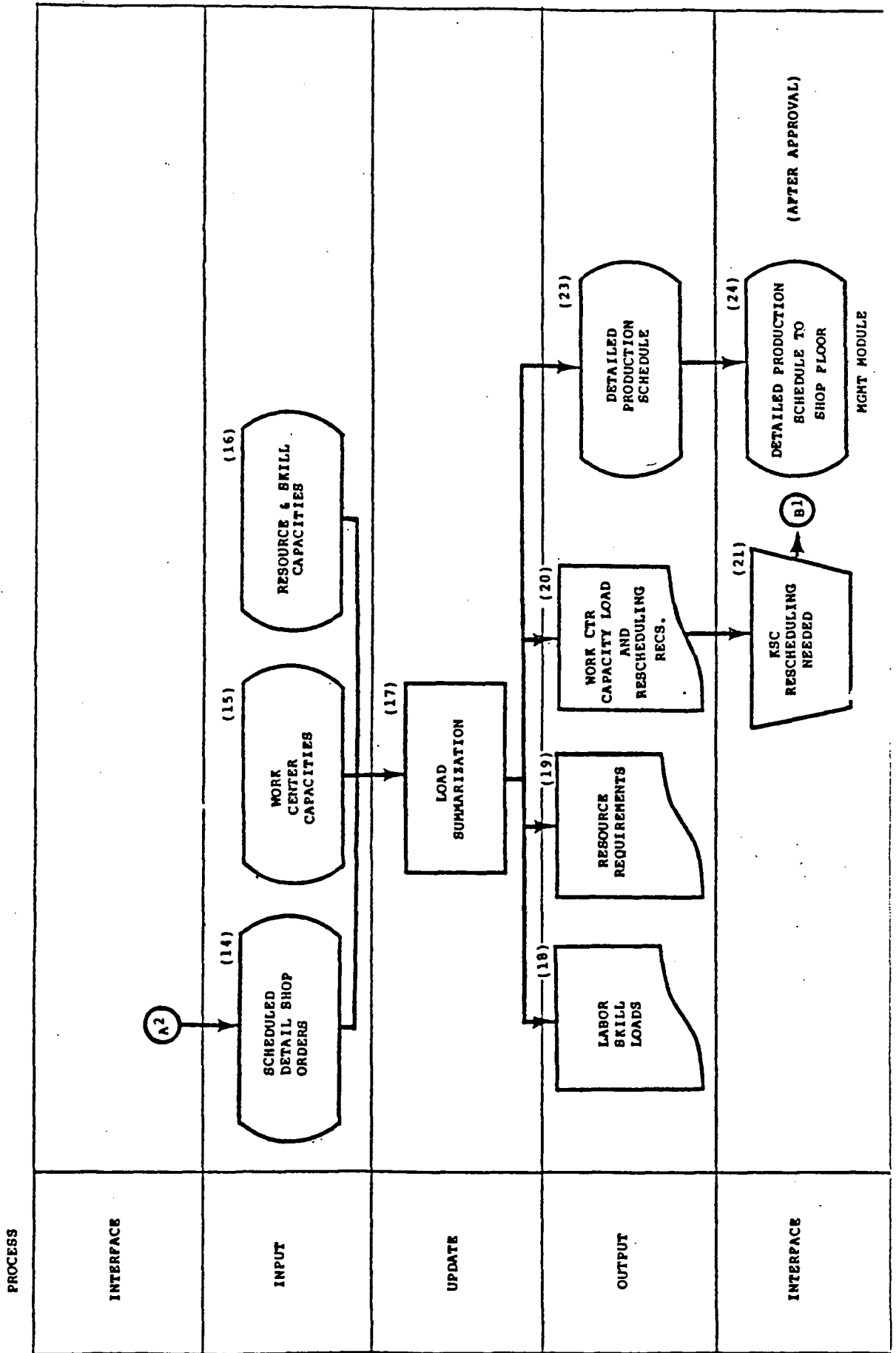


Figure V-3
Page 2 of 2

Automated Production Control System
Capacity Requirements Planning Subsystem



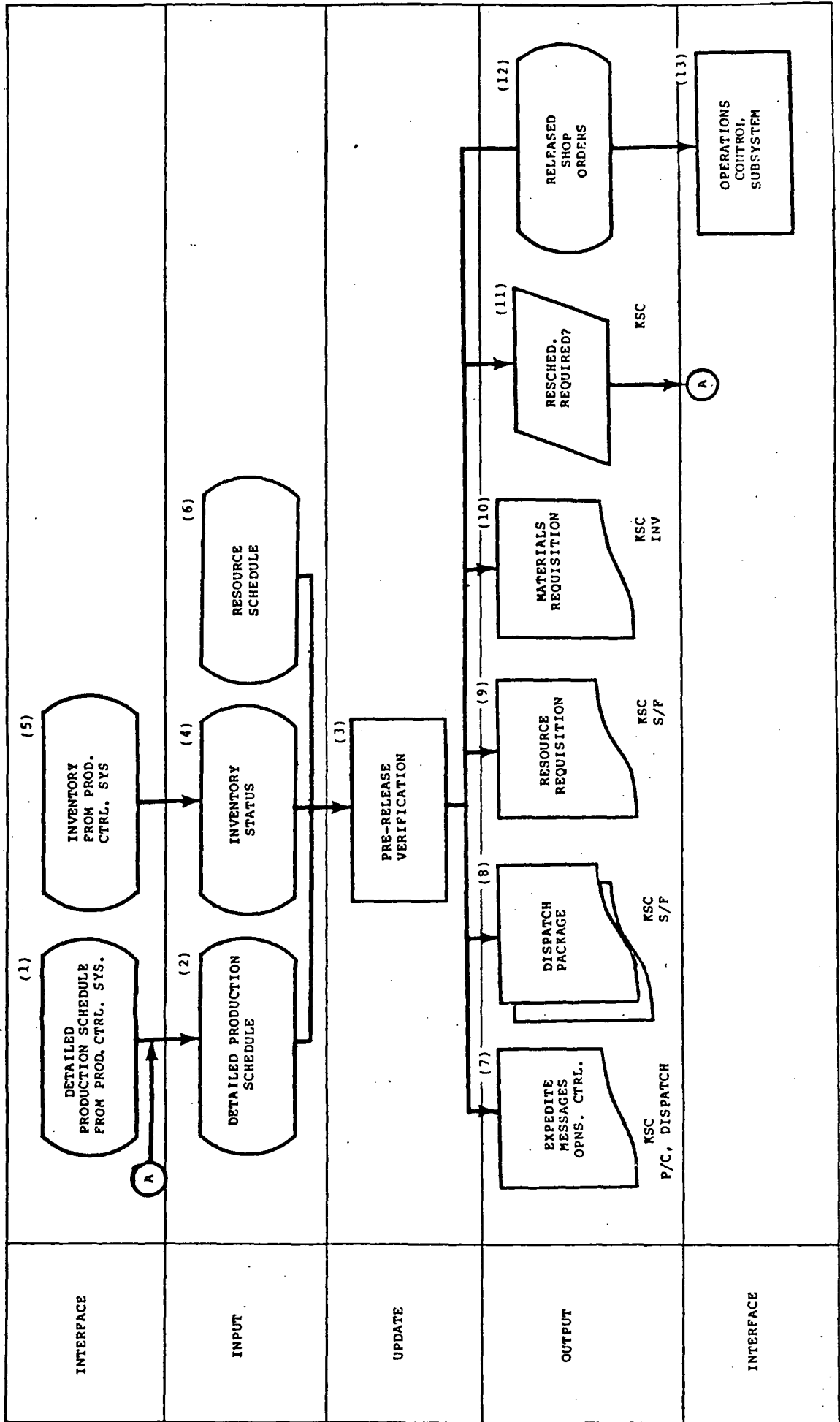
required (21). Should there be a requirement for rescheduling, the shop orders are rescheduled and reinput with the time-phased shop orders (22) and the detailed scheduling module is reexecuted. The major output of the capacity requirements planning subsystem is the detailed production schedule file (23) which is then passed to the shop floor management subsystem (24).

(d) Shop Floor
Management
Subsystem

The detailed production schedule (1) from the capacity requirements planning subsystem is input to the shop floor management system (Figure V-4) as the detailed production schedule (2). In order for prerelease verification to take place (3), the detailed production schedule is compared with current inventory status of parts (4) to determine if the required materials are available, and with the resource schedule file (6) to determine if the required resources are available. The inventory status file is maintained in the automated production control system (5). As a result of the prerelease verification module, several outputs are produced. Expedite messages (7) are produced to expedite the availability of parts or materials required for the detailed production schedule. A dispatch package is printed to authorize work to begin on operations in a detailed production schedule for which parts or materials and resources are available (8). Resource requisitions are printed (9) to draw upon resources; and materials requisitions are printed (10) to draw the materials required for the shop orders. Should some materials or resources not be available,

Figure V-4
Automated Production Control System

Shop Floor Management Subsystem



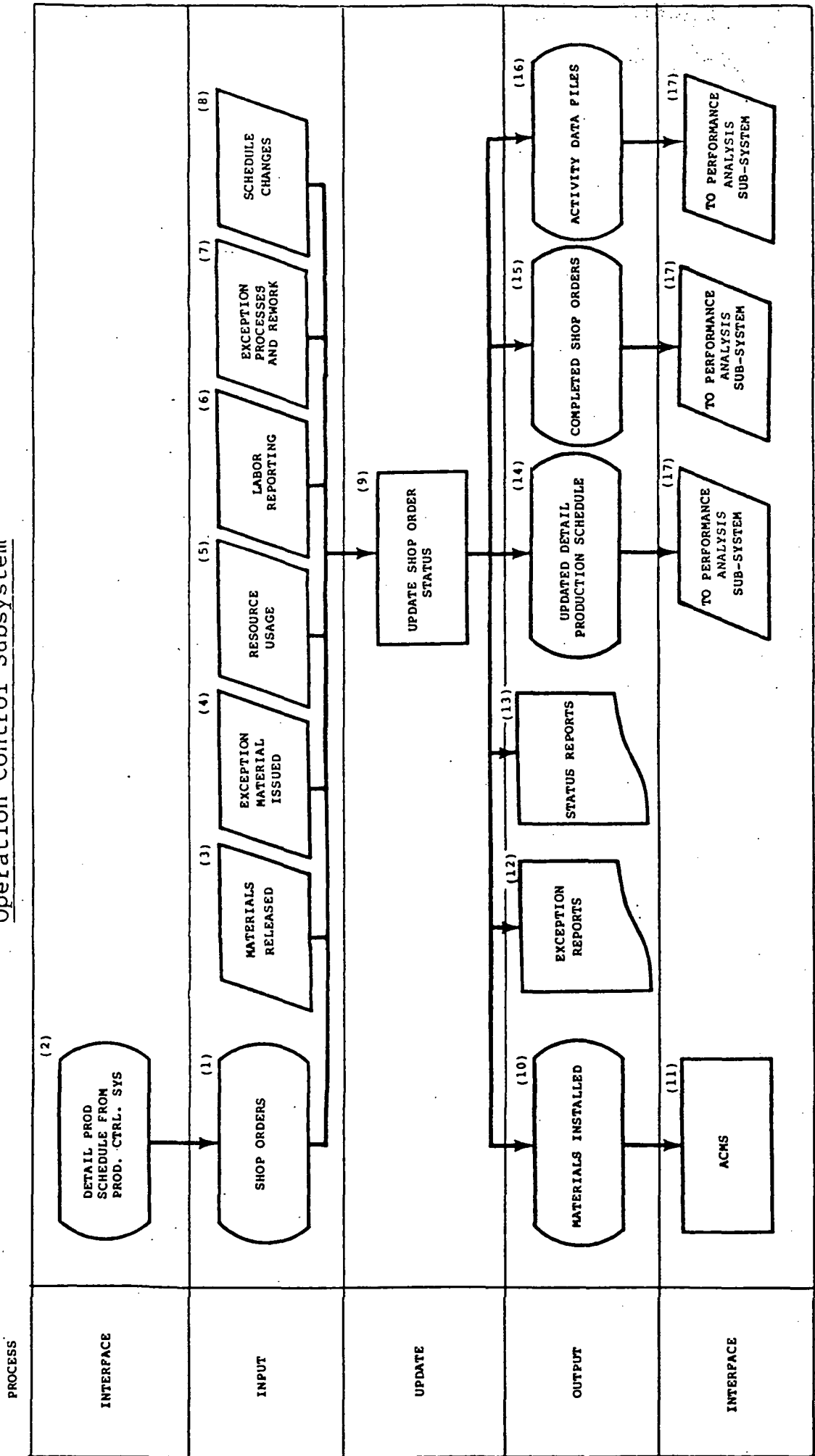
then there is a requirement to reschedule the shop order (11) and the shop order will be reinput in its rescheduled mode at the beginning of the shop floor management subsystem. The released shop orders (12) are then passed to the operations control subsystem (13).

(e) Operations
Control
Subsystem

The released shop orders (1) are passed to the operations control system (Figure V-5) from the shop floor management subsystem (2). All activity against the released shop order is posted to the shop order file. This includes materials released for the shop order (3), exception material issued to the shop order (4), resource usage against a shop order (5), labor expended for a shop order (6), exception processes and rework for the shop order (7), and schedule changes to the shop order (8). These activities are posted against the shop order file (9). A file of materials installed against the shop order (10) is maintained and utilized by the automated configuration management system to produce the "delta" reports showing variances between the "as designed" configuration and the "as built"* configuration (11). Exception reports are produced as necessary (12). Status reports of the shop orders are produced (13). Files are maintained of updated shop orders (14), completed shop orders (15), and all activity posted against

* This comparison between "as built" versus "as designed" will probably not be in sufficient detail to satisfy the NASA buy-off requirements. As a result ACMS, or a similar system, will probably be needed.

Figure V-5
 Automated Production Control System
 Operation Control Subsystem



the shop orders (16). These files are passed to the performance analysis subsystem (17).

(f) Performance
Analysis
Subsystem

The operations control subsystem provides three files (1) to the performance analysis subsystem (Figure V-6). These files are the updated shop orders completed shop orders and activity data. These three files are input to the performance analysis subsystem (2) and are used to compare actual performance against the plan (3). Various reports are produced, including the scheduled performance report (4), the labor performance report (5), the work center performance report (6), the cost performance report (7) and the operations budget performance report.

FILE DEFINITIONS

Each of the files depicted in the high-level flowcharts is described in more detail in this section.

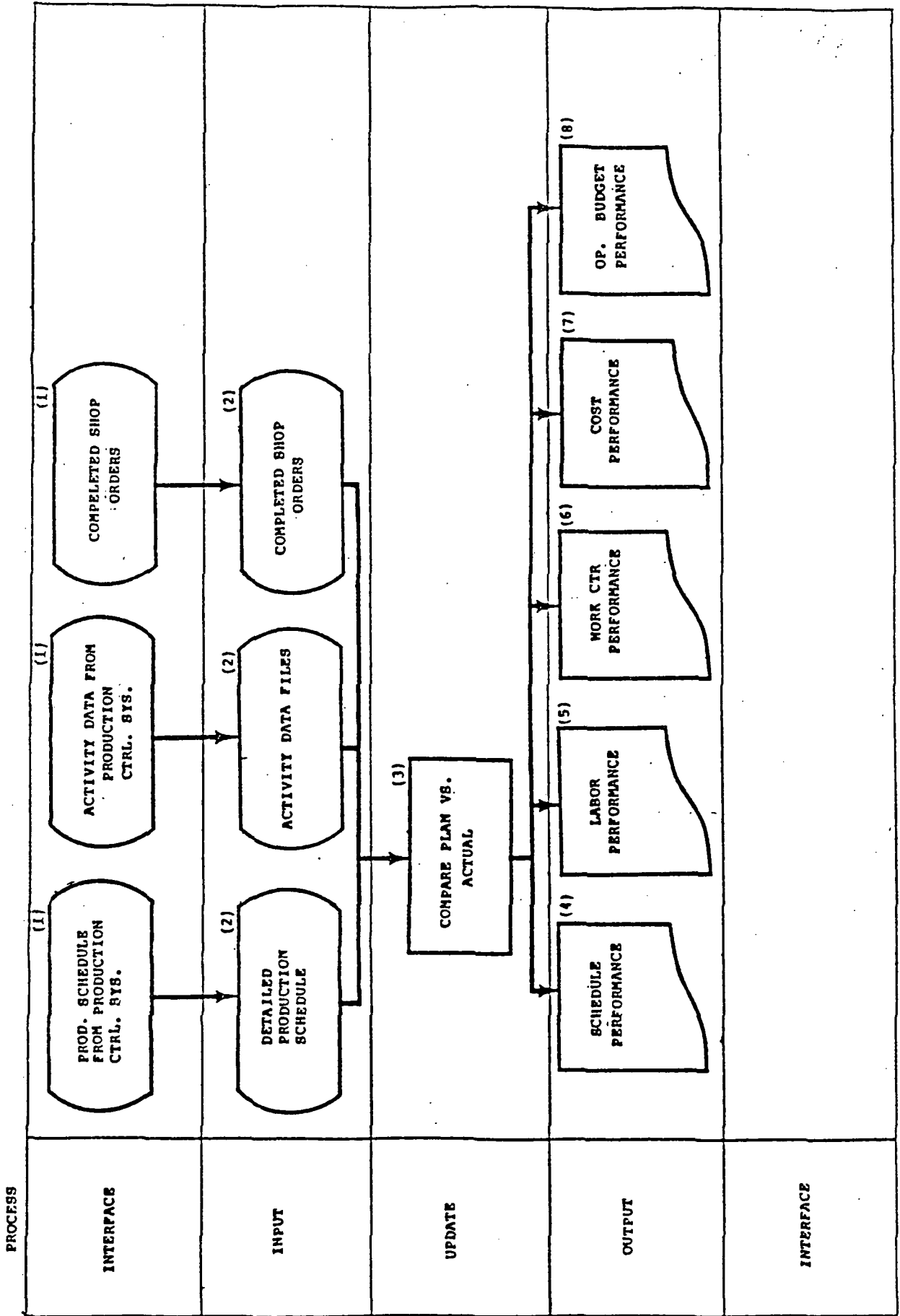
Each file is described as follows:

1. Purpose. The reason for the file's existence.
2. Source. Which functional organization creates and/or maintains the file.
3. Mode of Input. The type of input medium used to create and/or maintain the file.
4. Key Data Elements. The primary data fields associated with the file and estimated field lengths. The total of the field

Figure V-6

Automated Production Control System

Performance Analysis Subsystem



lengths is the estimated record length of the file. It is recognized that in actual operation the record may contain additional data fields for other internal or external system purposes. The probable key(s) to each file are denoted.

5. Number of Records. An estimate for the number of records each file will contain.

6. File Size. The record length times the estimated number of records.

7. Processing Location. Where in the system the file is created, processed, and/or maintained.

8. Peripheral Requirements. The noncentral hardware requirements required to create/maintain and print the file. Each piece of hardware is designated with a code number which will be referred to in Section VIII.

9. Access Requirement. The time frame during the day when the file must be accessible for on-line use.

10. Criticality of Response Time. An estimate of the need for quick response to use of the file.

11. Security Requirements. A classification of the measures that should be used to prevent unauthorized access to the file. The classification scheme is described in a previous section.

12. Backup Requirements. A classification of the actions that should be taken to ensure the capability to restore the file should the need occur. The classification scheme is described in a previous section.

Besides presenting an overview of the APC data requirements,

this section develops the volume estimates used to identify the disk storage requirements in Section VIII. A summary of the files completes this section.

(a) Launch Schedule
File

Purpose

This file is input to the master scheduling module. It represents the customer's orders for which material, labor, and other resources will eventually be scheduled to build the required solid rocket boosters.

Source

NASA provides the launch schedule to USBI.

Mode of Input

It is anticipated that the Master Scheduling Subsystem will be manual during the early project stages. When the subsystem is automated at a later date, the mode of input would be direct entry through a CRT or punched cards.

Key Data Elements

<u>Name</u>	<u>Estimated Field Length</u>
1. Launch Number (Key)	N3
2. Launch Date	<u>N6</u>
Total	9 Bytes

Number of Records

One per flight; total number dependent upon number of flights

being scheduled. For purposes of estimating related files, it is assumed that 200 flights are being scheduled (representing a five-year time frame).

File Size

200 records x record length of 9 = 1800 bytes = .002 megabytes (MB).

Processing Location

Entry to be done at USBI (Resource Planning).

Peripheral Requirements

One CRT (designated A1); one printer (designated P1).

Access Requirement

As required.

Criticality of Response Time

Medium.

Security Requirements

Medium.

Backup Requirements

Low.

(b) Major Assembly
Manufacturing
Bill of
Materials

Purpose

This file is input to the master scheduling module and is

used with the launch schedule file to determine the due dates for each of the major assemblies associated with each flight.

Source

This file is extracted from the automated production control system manufacturing bill of materials.

Mode of Input

Interface from Automated Production Control System.

Key Data Elements

<u>Name</u>	<u>Estimated Field Length</u>
1. Part Number (Key)	A15
2. Part Description	A26
3. Final Assembly Lead Time	<u>R3</u>
Total	44 Bytes

Number of Records

Estimated to be thirty major assemblies per SRB flight set.

File Size

30 x 44 = 1,320 bytes = .001 MB.

Processing Location

In the central computer.

Peripheral Requirements

None.

Access Requirements

As required.

Security Requirements

Medium.

Backup Requirements

Low.

(c) Major Assembly
Inventory File

Purpose

This file is used to determine if major assemblies currently exist in stock.

Source

This file is extracted from the automated production control system inventory status file.

Mode of Input

Interface from Automated Production Control System.

Key Data Elements

<u>Name</u>	<u>Estimated Field Length</u>
1. Part Number (key)	A15
2. Quantity-on-Hand/Planned	R2
3. Due Date (if planned)	<u>N6</u>
Total	23 Bytes

Number of Records

Thirty (one for each major assembly) per flight set x 200
flight sets = 6,000.

File Size

6,000 x 23 = 138,000 bytes = .138 MB.

Processing Location

Within central computer.

Peripheral Requirements

None.

Access Requirements

As required.

Security Requirements

Medium.

Backup Requirements

Low.

(d) Major Assembly
New Build Orders
File

Purpose

This file is used to provide the scheduled receipt dates
of new major assemblies.

Source

This file is extracted from the automated production
control system new build order file.

Mode of Input

Interface from Automated Production Control System.

Key Data Elements

<u>Name</u>	<u>Estimated Field Length</u>
1. Part Number (Key)	A15
2. Scheduled Completion Date	N6
3. Quantity To Be Completed	<u>R2</u>
	Total 23 Bytes

Number of Records

Dependent upon number of new assemblies being built.

Probably would not exceed 100 at any given time.

File Size

$100 \times 23 = 2,300 \text{ bytes} = .002 \text{ MB.}$

Processing Location

Within central computer.

Peripheral Requirements

None.

Access Requirements

As required.

Security Requirements

Medium.

Backup Requirements

Low.

(e) Major Assembly
 Refurbishment
Schedule File

Purpose

This file is used to provide the estimated scheduled receipt dates of refurbished major assemblies.

Source

This file is created in the master scheduling module by calculation. For each refurbishable assembly, "x" days are added to the launch date for SRB recovery, and then the average refurbishment lead time is added to determine the estimated date for scheduled receipt of the refurbished major assembly.

Mode of Input

None; this file is created.

Key Data Elements

<u>Name</u>	<u>Estimated Field Length</u>
1. Part Number (Key)	A15
2. Scheduled Receipt Date	<u>N6</u>
Total	21 Bytes

Number of Records

Estimated to be 10 per launch. For the assumption of a 200-launch horizon, there would be 2,000 records.

File Size

$2,000 \times 21 = 42,000 \text{ bytes} = .042 \text{ MB.}$

Processing Location

Within central computer.

Peripheral Requirements

None.

Access Requirements

As required.

Security Requirements

Medium.

Backup Requirements

Low.

(f) Major Assembly
Gross
Requirements

Purpose

This file represents the due dates for completion of major assemblies to accomplish the launch schedule.

Source

This file is created in the master scheduling module by using the launch dates from the launch schedule file and the major assembly requirements and lead times to determine the due dates of major assemblies and activities.

Mode of Input

None, this file is created in the master scheduling module.

Key Data Elements

<u>Name</u>	<u>Estimated Field Length</u>
1. Major Assembly Number (key)	A15
2. Description	A26
3. Due Date	<u>N6</u>
Total	47 Bytes

Number of Records

30 per launch. Assuming a planning horizon of 200 launches, there would be 6,000 records.

File Size

$6,000 \times 47 = 282,000$ bytes = .282 MB.

Processing Location

Within central computer.

Peripheral Requirements

None.

Access Requirements

As required.

Security Requirements

Medium.

Backup Requirements

Low.

(g) Summary Resource Requirements File

Purpose

The purpose of this file is to provide for each major assembly the time-phased estimated resource requirements (e.g., labor by skill level, material, facility, and ground support) for gross capacity planning and operations budgeting.

Source

Provided and maintained by USBI (Resource Planning).

Mode of Input

One time setup via terminal or punched cards; ongoing on-line maintenance through terminal with estimated volume of 30 transactions per quarter.

Key Data Elements

<u>Name</u>	<u>Estimated Field Length</u>
1. Major Assembly Number	A15
2. Resource Type Number*	80 x R2
2.1 Resource Quantity Needed by Time (months)	6 x R2
2.2 Unit of Measure	<u>R2</u>
Total	1,295 Bytes

Note: (*) Includes Labor by Department and Critical Skills (10), Critical Work Centers (10), Facilities (10), Materials Commodity Class (15), Supplies (5), GSE Class (10), Subcontractors (15), Other (5).

Number of Records

30.

File Size

1,295 x 30 = 38,850 bytes = .039 MB.

Processing Location

Input via CRT from USBI headquarters, Huntsville.

Peripheral Requirements

One CRT (designated A1); one printer (designated P1).

Access Requirements

0800-1700 Daily.

Criticality of Response Time

Medium.

Security Requirements

Critical.

Backup Requirements

High.

(h) Summary Resource
Availability File

The purpose of this file is to identify planned availability of resource by time period (monthly for five years).

Source

Provided and maintained by USBI (Resource Planning).

Mode of Input

One-time setup via terminal or punched cards; ongoing on-line maintenance through terminal with estimated volume of 4,800 transactions per year.

Key Data Elements

<u>Name</u>	<u>Estimated Field Length</u>
1. Resource Type	R2
2. Resource Description	A26
3. Quantity Available	R2
4. Month	N6
5. Unit of Measure	<u>R2</u>
Total	38 Bytes

Number of Records

4,800 (1 per resource type (80) per month (60)).

File Size

4,800 X 38 = 182,400 bytes = .182 MB.

Processing Location

Input via CRT from USBI Headquarters, Huntsville.

Peripheral Requirements

One CRT (designated A1).

Access Requirements

0800-1700 Daily.

Criticality of Response Time

Medium.

Security Requirements

Critical.

Backup Requirements

High.

(i) SRB/Major
Assembly
Manufacturing
Orders File

Purpose

This file represents the manufacturing orders necessary to meet the launch schedule and is passed to the detailed scheduling module of the automated production control system.

Source

This file is created in the master scheduling module using the major assembly refurbishment schedule, gross requirements, current inventory, and new build orders files.

Mode of Input

None; created in master scheduling module.

Key Data Elements

<u>Name</u>	<u>Estimated Field Length</u>
1. Major Assembly/Number (key)	A15
2. Due Date	N6
3. STS Number (key)	R2
4. Order Type (new or refurb)	A1
5. Major Assembly Serial Number	<u>A10</u>
Total	34 Bytes

Number of Records

Assuming a launch horizon of 200 flights, and 30 major assemblies per flight, there would be up to 6,000 records (some major assemblies may be in stock or be work-in-process).

File Size

$6,000 \times 34 = 204,000$ bytes = .204 MB.

Processing Location

Within central computer.

Peripheral Requirements

None.

Access Requirements

As required.

Security Requirements

Medium.

Backup Requirements

To be backed up immediately after each creation.

(j) Manufacturing
Bill Of Material
File

Purpose

The Bill of Material (BOM) File provides the parts and their relationship to higher/lower assemblies data necessary to explode the major assembly requirements into the components and parts that make up those assemblies. It also provides the lead time necessary to acquire or assemble a part/component.

Source

The current engineering BOM is maintained in the engineering data base. The manufacturing BOM is extracted from that data base.

Mode of Input

None; the file is maintained through an integration with the engineering data base.

Key Data Elements

<u>Name</u>	<u>Estimated Field Length</u>
1. Parent Part Number	A15
2. Component Part Number	A15
3. Quantity Used	R4
4. Find Number	I2
5. Effectivity (by STS Numbers From/To)	2 x I3
6. Unit of Measure	2 X I2
7. Engineering Change Number	R2
8. Engineering Change Date	N6
9. Drawing Number	<u>A10</u>
Total	64 Bytes

Number of Records

There are an estimated 250,000 items in the bill of material, assuming effectivity changes by line item or component record.

File Size

250,000 x 64 = 16,000,000 bytes = 16.0 MB.

Processing Location

USBI/HSV Design Engineering; USBI/KSC Process Engineering;
USBI/KSC Quality Assurance.

Peripheral Requirements

3 CRTs (designated A2, A3, and K1); 2 Printers (designated P1 and P2).

Access Requirements

24 hours per day.

Criticality of Response Time

High.

Security Requirements

High.

Backup Requirements

High.

(k) Inventory File

Purpose

This file is a multipurpose file. In addition to tracking inventory levels through issues, receipts, cycle counts, and adjustments, the inventory data base provides the key record for storing other records (e.g., serialized part information, configuration data).

Source

The file is primarily maintained by the inventory control function of the production control system.

Mode of Input

Assuming 50,000 controlled parts per SRB, there are likely to be 1,000,000 transactions in the system on an annual basis (i.e., 12 flows + additional stock). Therefore, the mode of

input will be through CRT with transaction volumes as follows:

Issues	:	1,000,000/Year = 3,200/day
Receipts	:	1,000,000/Year = 3,200/day
Inspections	:	1,000,000/Year = 3,200/day
Moves/Adjustments	:	1,000,000/Year = <u>3,200/day</u>
Total		12,800/day

Key Data Elements

<u>Name</u>	<u>Estimated Field Length</u>
1. Part Number	A15
2. Effectivity (STS From/To or Date)	3 x I2 or N6
3. Part Description	A26
4. Class Code	I1
5. ABC Code	A2
6. Source Code	A2
7. Unit of Measure	A2
8. Inventory Account Number	
9. Reorder Point	R2
10. Last Engineering Change Order	A15
11. Issue Date	I2
12. Received Date	I2
13. Last Cycle-Count Date	I2
14. Quantity-on-Hand	R4
15. Usage Data	5 X R2
16. Material Cost Data	5 X R2
17. Labor Cost Data	5 X R2
18. Order Policy Data	5 X R2
19. Lead Time Data	2 X R2
20. Safety Stock	R2
21. MRP Level Code	I2
Total	129 Bytes

Number of Records

There are approximately 6,000 parts being tracked by current inventory systems. However, a subrecord for serialized parts will also exist. It is estimated that 50,000 controlled parts will be required for each flight. Assuming a flow of 10 to 12

flights, there will be 500,000 to 600,000 records.

File Size

600,000 x 129 = 77,400,000 bytes = 77.4 MB.

Processing Location

Inventory Segregation Areas (KSC).
USBI Headquarters, Huntsville.

Peripheral Requirements

Based on 12,800 transactions per day, and a 20-hour day, the processing rate would be 640 transactions per hour. Assuming a throughput of 60 transactions per hour per terminal, 11 CRTs would be required. An additional 6 CRTs would be provided for inquiry and maintenance for a total of 17 CRTs, 14 in KSC (designated K2 through K15), and 2 in Huntsville (designated A4, A5). Two printers (P3, P4) would be needed at KSC; printer P1 can be used for Huntsville.

Access Requirements

24 hours per day.

Criticality of Response Time

High.

Security Requirements

High.

Backup Requirements

High.

(1) Purchase Order
Request File

Purpose

In addition to its use in a purchasing system (off-line), the purchasing order request file would be used by the MRP module to provide data related to scheduled receipts of materials.

Source

Interface from purchasing subsystem (off-line).

Mode of Input

None; extracted from purchasing subsystem (off-line).

Key Data Elements

<u>Name</u>	<u>Estimated Field Length</u>
1. Part Number (key)	A15
2. Purchase Order Number	A10
3. Order Quantity	R2
4. Purchase Order Unit Cost	R2
5. Due Date	I2
6. Vendor-Promised Delivery Date	I2
7. User-Specified Delivery Date	I2
8. Quantity Returned to Vendor	R2
9. Vendor Code	A10
10. Account Number	<u>A10</u>
Total	57 Bytes

Number of Records

Estimated to be about 1,000 open P.O.'s.

File Size

1,000 x 57 = 57,000 bytes = .057 MB.

Processing Location

USBI/HSV (Purchasing).

Hardware Requirements

Two CRTs for purchasing designated A4 and A5. One printer (designated P1).

Access Requirements

24 hours per day.

Criticality of Response Time

Medium.

Security Requirements

Medium.

Backup Requirements

High.

(m) Gross Requirements File

Purpose

The gross requirements file contains all the assemblies/parts required to meet the master schedule.

Source

Created in the MRP module.

Mode of Input

None; it is a created file.

Key Data Elements

<u>Name</u>	<u>Estimated Field Length</u>
1. Part Number/Effectivity (key)	A15
2. Required Quantity	R2
3. Required Date	I2
4. STS Number	R2
5. Next Higher Assembly	A15
6. Serial Number	<u>A10</u>
Total	46 Bytes

Number of Records

Assuming a launch horizon of 120 flights and 50,000 assembly parts per flight, there would be 6,000,000 records.

File Size

$6,000,000 \times 46 = 276,000,000$ bytes = 276 MB.

Processing Location

Within central computer.

Peripherals Required

None.

Access Requirements

As required.

Security Requirements

High.

Backup Requirements

High; this file should be backed up immediately after creation.

(n) Manufacturing
Order File

Purpose

The purpose of the manufacturing order file is to provide the information regarding the due dates of assemblies required during the manufacturing process.

Source

This file is created through the netting logic of the MRP module.

Mode of Input

None, it is created by the Material Requirements Planning Subsystem.

Key Data Elements

<u>Name</u>	<u>Estimated Field Length</u>
1. Part Number/Effectivity (key)	A15
2. Planned Quantity	R2
3. Start Date	I2
4. Due Date	I2
5. Next Higher Assembly	A15
6. Launch Number	<u>I2</u>
Total	38 Bytes

Number of Records

Assuming a launch horizon of 120 flights, and up to 50,000 manufacturing orders required per flight, there could be up to 6,000,000 records.

File Size

$6,000,000 \times 38 = 228,000,000$ bytes = 228 MB.

Processing Location

Within central computer.

Peripheral Requirements

None.

Access Requirements

24 hours per day.

Criticality of Response Time

High.

Security Requirements

High.

Backup Requirements

Critical.

(o) Routing File

Purpose

The routing file provides the detailed operations for each shop order, showing work centers, operations, GSE requirements, tooling requirements, and labor requirements by skill.

There would also be routings to: (1) upgrade the effectivity of a part; (2) rework a part to flightworthy status; and (3) other purposes as required.

Source

This file is maintained in conjunction with the Work Authorization Document system by USBI/KSC (Process Engineering).

Mode of Input

Batch one time setup. On-line maintenance (daily).

Key Data Elements

<u>Name</u>	<u>Estimated Field Length</u>
1. Part Number (key)	A15
2. Sequence Number	I2
3. Operation Code (key)	A10
4. Operation Description	A30
5. Tool Numbers	5 x A10
6. Work Center	A10
7. Standard Setup Hours	R2
8. Standard Run Hours	R2
9. Standard Transit/Queue Hours	R2
10. GSE Requirements	5 x A20
11. Labor Skill/Certification Requirement	<u>5 x A30</u>
Total	373 Bytes

Number of Records

20 Flts x 250 Routings = 5,000 Records + 1,000 Baseline

Routings = 6,000 records x 5 operations per routing =
30,000 records.

File Size

30,000 x 373 = 11,190,000 bytes = 11.19 MB.

Processing Location

Used within central computer; maintained by USBI/KSC
Process Engineering.

Peripheral Requirements

1 CRT (K60)

Access Requirements

24 hours daily.

Criticality of Response Time

Medium.

Security Requirements

High.

Backup Requirements

High.

(p) Exception Process
Documents File

Purpose

To provide work orders for exception processes (TPS, DR, PR)
for incorporation in the scheduling module.

Source

USBI/KSC Shop Floor and USBI/KSC Process Engineering.

Mode of Input

CRT.

Key Data Elements

<u>Name</u>	<u>Estimated Field Length</u>
1. Part Number (key)	A15
2. Sequence Number	I2
3. Operation Code (key)	A10
4. Operation Description	A30
5. Tool Numbers	5 x A10
6. Work Center	A10
7. Standard Setup Hours	R2
8. Standard Run Hours	R2
9. Standard Transit/Queue Hours	R2
10. GSE Requirements	5 x A20
11. Labor Skill/Certification Requirement	<u>5 x A30</u>
Total	373 Bytes

Number of Records

Estimated to be 4,000 records; ongoing maintenance estimated to be 25 records per day.

File Size

$373 \times 4,000 = 1,492,000$ bytes = 1.49 MB.

Processing Location

USBI/KSC Shop Floor and Process Engineering.

Peripheral Requirements

2 CRTs (K1, K16), in addition to shop floor terminals.

Access Requirements

24 hours per day.

Criticality of Response Time

High.

Security Requirements

High.

Backup Requirements

High.

(q) Process
Constraints
File

Purpose

To identify specific routings that prohibit the simultaneous performance of other routings due to the nature of the specific routing.

Source

USBI/KSC (Process Engineering).

Mode of Input

CRT.

Key Data Elements

<u>Name</u>	<u>Estimated Field Length</u>
1. Part Number/Routing Number	A15
2. Operation Code	A10
3. Network Structure Codes	<u>X</u> (To be determined)
	X (To be determined)

Number of Records

To be determined.

File Size

To be determined.

Processing Location

Within central computer.

Peripheral Requirements

1 CRT (K1).

Access Requirements

24 hours per day.

Criticality of Response Time

Medium.

Security Requirements

High.

Backup Requirements

Medium.

(r) GSE Preventive
Maintenance Work
Orders

Purpose

To provide work orders for preventive maintenance for scheduling purposes.

Source

Input by USBI/KSC (Preventive Maintenance).

Mode of Input

By CRT daily.

Key Data Elements

<u>Name</u>	<u>Estimated Field Length</u>
1. Part Number (key)	A15
2. Sequence Number	I2
3. Operation Code (Key)	A10
4. Operation Description	A30
5. Tool Numbers	5 x A10
6. Work Center	A10
7. Standard Setup Hours	R2
8. Standard Run Hours	R2
9. Standard Transit/Queue Hours	R2
10. GSE Requirements	5 x A20
11. Labor Skill/Certification Requirement	<u>5 x A30</u>
Total	373 Bytes

Number of Records

500 (Estimated).

File Size

500 x 373 = 186,500 bytes = .187 MB.

Processing Location

Input at KSC (Preventive Maintenance); processed in central computer.

Peripheral Requirements

One CRT (K17) at KSC.

Access Requirements

24 hours per day.

Criticality of Response Time

Medium.

Security Requirements

Medium.

Backup Requirements

Medium.

(s) Work Center/
Capacity File

Purpose

The purpose of this file is to describe a unique work center and its capacity.

Source

Created on a one-time basis; maintained thereafter by
USBI/KSC Process Engineering.

Mode of Input

Maintained through CRT.

Key Data Elements

<u>Name</u>	<u>Estimated Field Length</u>
1. Work Center Number	A10
2. Description	A30
3. Capacity Hours/Day	R2
4. Setup Rate	R2
5. Labor Rate	R2
6. Utilization Data	52 X R2
7. Reserved	<u>A20</u>
Total	170 Bytes

Number of Records

Estimated to be 100 records.

File Size

$100 \times 170 = 17,200 \text{ bytes} = .017 \text{ MB.}$

Peripheral Requirements

1 CRT (K60).

(t) Resource Skill
Capacities File

Purpose

The purpose of this file is to identify the capacity levels by resource type.

Source

Created and maintained by USBI/KSC Process Engineering.

Mode of Input

CRT.

Key Data Elements

<u>Name</u>	<u>Estimated Field Length</u>
1. Resource Number	A10
2. Description	A30
3. Capacity Hours/Day	R2
4. Setup Rate	R2
5. Labor Rate	R2
6. Utilization Data	52 X R2
7. Reserved	<u>20</u>
Total	170 Bytes

Number of Records

One each per resource type (80) and labor skill (100) = 180 records.

File Size

180 x 170 = 30,600 bytes = .031 MB.

Processing Location

Maintained by Process Engineering/USBI.

Peripheral Requirements

1 CRT (K1).

Access Requirements

24 hours per day.

Criticality of Response Time

Medium.

Security Requirements

High.

Backup Requirements

High.

(u) Time-Phased
Shop Orders

(Scheduled Detail Shop Orders)
(Activity Data File)
(Detailed Production Schedule)
(Completed Shop Order File)

Purpose

The purpose of the shop order file is to provide the detailed operations/shop order for scheduling, posting, and performance analysis.

Source

This file is created by applying the manufacturing orders

to the routing file, then updated in the detailed scheduling module, and updated through the rescheduling process. It is also updated in the operations control subsystem.

Mode of Input

None; this file is created and maintained by various input transactions.

Key Data Elements

<u>Name</u>	<u>Estimated Field Length</u>
1. Shop Order Number (Key)	A10
2. Sequence Number	I1
3. Operation Code (Key)	A7
4. Work Center (Key)	A7
5. Quantity Required	R2
6. Quantity Completed	R2
7. Start Date Offset	I2
8. End-Date Offset	I2
9. Standard Setup Hours	R2
10. Actual Setup Hours	R2
11. Standard Run Hours	R2
12. Actual Run Hours	R2
13. Labor Skill Certifications	R2
14. Labor Skill Standard Names	R2
15. Supplies	R2
16. Supplies Quantity	R2
17. Tools	R2
18. Tools Time Required	R2
19. GSE	R2
20. GSE Time Required	R2
21. Subcontractor	R2
22. Subcontractor Time Required	R2
23. Start Date	R2
24. Latest Complete Date	I2
25. Priority	I1
26. Part/Effectivity/Serial Number	<u>A30</u>
Total	96 Bytes

Number of Records

Assuming 1,000 per SRB (12) = 12,000 + additional for preventive maintenance, TPS, PR, DR (40%) = 16,800.

File Size

16,800 x 96 = 1,612,800 bytes = 1.61 MB.

Processing Location

Created within central computer. Modified by USBI/KSC
(Production Control).

Hardware Required

Five CRTs (designated K61 through K65) and one printer
(designated P5) would be required at KSC.

Access Requirements

24 hours per day.

Criticality of Response Time

High.

Security Requirements

High.

Backup Requirements

High.

(v) Resource
Schedule File

Purpose

This file provides data relating to the availability of re-
sources required to work a shop order at the time of prerelease
verification, in order to ascertain that those resources will be
available at the time the shop order is released to the floor.

Source

Generated by production scheduling functions.

Mode of Input

None; maintained within central computer.

Key Data Elements

<u>Name</u>	<u>Estimated Field Length</u>
1. Resource Code (key)	A10
2. Resource Description	A30
3. Resource Requirement	R2
4. Resource Requirement Load Factor	R2
5. Time Period	R2
6. Shop Order Operation	<u>A10</u>
Total	56 Bytes

Number of Records

80 (one for each resource type) for each time period
(12 per day x 30 days) = 360.

File Size

80 x 360 = 28,800 bytes = .029 MB.

Processing Location

Within central computer.

Peripheral Requirements

None.

Access Requirements

24 hours per day.

Security Requirements

High.

Backup Requirements

High.

(w) Resource Usage
File

Purpose

The purpose of this file is to clock the utilization of tools, GSE, and other equipment against a shop order.

Source

USBI/KSC (Operations Control).

Mode of Input

CRT.

Key Data Elements

<u>Name</u>	<u>Estimated Field Length</u>
1. Shop Order Number	A15
2. Date	I2
3. Resource Type	A6
4. Date Started	I2
5. Time Started	I2
6. Date Complete	I2
7. Time Complete	I2
8. Work Center	A6
9. Operation Code	A7
Total	44 Bytes

Number of Records

Estimated to be 500 per day.

File Size

500 x 30 x 44 = 660,000 bytes = .66 MB.

Processing Location

Data entered through operations control work centers.

Peripheral Requirements

1 CRT per work center (K18-K59).

Access Requirements

24 hours daily.

Criticality of Response Time

High.

Security Requirements

High.

Backup Requirements

High.

(x) Exception
Processes And
Rework File

Purpose

To create additional shop orders to accommodate additional work requirements.

Source

USBI/KSC Operations Control.

Mode of Input

CRT.

Key Data Elements

<u>Name</u>	<u>Estimated Field Length</u>
1. Shop Order Number (key)	A15
2. Operation Code (key)	A10
3. Operation Description	A30
4. Operation Sequence	I2
5. Operation Work Center	A10
6. Operation Labor Certifications	5 x A30
7. Operation Resource Requirements	10 x A15
8. Special Notes	<u>To Be Determined</u>
	To Be Determined

Number of Records

To be determined.

File Size

To be determined.

Processing Location

USBI/KSC Process Engineering.

Peripherals Required

5 CRTs (K61-K65) in addition to operations control work stations.

Access Requirements

High.

Criticality of Response Time

High.

Security Requirements

High.

Backup Requirements

High.

(y) Labor Reporting File

Purpose

This file is used to report labor against a shop order.

Source

The source of data is from USBI/KSC Operations Control.

Mode of Input

While the expected mode of input is through a CRT, it will be advantageous in the future years to utilize a coded cards (magnetic strip or equivalent) input.

Key Data Elements

<u>Name</u>	<u>Estimated Field Length</u>
1. Shop Order Number	A15
2. Date	I2
3. Shift	I2
4. Time Clocked On	R2
5. Time Clocked Off	R2
6. Employee Identification	A6
7. Work Center	A6
8. Operations Code	A7
9. Labor Skill Certification	<u>A3</u>
Total	45 Bytes

Number of Records

Assuming 1,500 direct workers, and five operations each per day, there would be 7,500 records per day x 30 days of on-line access = 225,000.

File Size

225,000 x 45 = 10,125,000 bytes = 10.125 MB.

Processing Location

USBI/KSC Operations Control.

Peripheral Requirements

1 CRT per work station (K18-K59).

Access Requirements

24 hours daily.

Criticality of Reponse Time

High.

Security Requirements

High.

Backup Requirements

Low.

(z) Activity Data
File

Purpose

This file contains summarized activity data beyond the 30 days of detail kept in the APC. It is used in the performance evaluation subsystem.

Source

Created by Operations Control Subsystem.

Mode of Input

None, created from other files.

Key Data Elements

<u>Name</u>	<u>Estimated Field Length</u>
1. Shop Order Number	A10
2. Operation Time Log	R2
3. Work Center Number	A5
4. Work Center Standard Duration Time	R2
5. Work Center Actual Time	R2
6. Labor Certification Number	A10
7. Labor Certification Standard Time	R2
8. Labor Certification Actual Time	R2
9. Supplies Requisitioned	A10
10. Supplies Used	R2
11. Tools/GSE/Subcontractor Number	A10
12. Tools/GSE/Subcontractor Standard Duration Time	R2
13. Tools/GSE/Subcontractor Actual Time	<u>R2</u>
Total	61 Bytes

Number of Records

To be determined.

File Size

To be determined.

Processing Location

Within central computer.

Peripherals Required

None.

Access Requirements

As Required.

Security Requirements

High.

Backup Requirements

High.

The following table summarizes the file storage requirements.

Table V-1

File Summary

<u>File Name</u>	<u>Record Length</u>	<u>Number of Records</u>	<u>File Size (bytes)</u>
Launch Schedule	9	200	1,800
Major Assembly BOM	44	30	1,320
Major Assembly Inventory	23	6,000	138,000
Major Assembly New Build Orders	23	100	2,300
Major Assembly Refurb Schedule	21	2,000	42,000
Major Assembly Gross Requirements	47	6,000	28,200
Summary Resource Requirements	1,295	30	38,850
Summary Resource Availability	38	4,800	182,400
Major Assembly Manufacturing Orders	34	6,000	204,000
Manufacturing BOM Inventory	60	250,000	16,000,000
	127	600,000	77,400,000
Purchasing Order Request	57	1,000	57,000
Gross Material Requirements	47	6,000,000	276,000,000
Manufacturing Order File	38	6,000,000	228,000,000
Routings File	373	30,000	11,190,000
Exception Process Documents File	373	4,000	1,492,000
Process Constraints File			To Be Determined
P.M. Work Orders	373	500	186,500
Work Center Capacity	172	2,100	17,200
Shop Orders	96	16,800	1,612,800
Resource/Skill Capacity	172	180	30,960
Resource Schedule			
Resource Usage	44	1,500	66,000
Exception Process and Rework			To Be Determined
Labor Reporting	45	225,000	10,125,000
Activity Data File			<u>To Be Determined</u>
		Total	<u>622,816,330 + "TBD"</u>

EVALUATION OF
EXISTING NASA
SYSTEMS

A key consideration by the project team was the possibility of using existing NASA or USBI systems to perform all or a part of the functional requirements for the Automated Production Control System.

Accordingly, the project team reviewed the capabilities of existing NASA and USBI systems to determine whether those systems should:

1. Be integrated into the APC System and thus perform some portion of its functional requirements, or
2. Interface with the APC System either to perform some APC function or to provide a supporting function to the APC, or
3. Be replaced by the APC System, or
4. Exist coincidentally with the APC System for some other purpose.

The conclusions of the project team follow.

(a) SIMS/SIMS II

KSC's primary purpose in providing SIMS to its contractors was twofold: (1) to provide GSA with the ability to review contractor inventory levels; (2) to provide a contractor-integrated inventory system that may lend itself to contract swapping of needed inventory.

SIMS is a basic inventory system, processing receipts and

issues of inventory and producing weekly and monthly reports of inventory status and activity. USBI was the first shuttle contractor to utilize SIMS; however, they utilize it in a "parallel mode" only and rely on internal systems for actual inventory control. The system suffers from poor response time, due in part to inadequate hardware resource allocation.

Additional difficulties with the system have been noted and a new set of functional requirements for SIMS II have been issued. It is anticipated that the current SIMS will be redeveloped and redeployed using more current hardware and software.

It is not recommended that SIMS or SIMS II be utilized in place of, or to supplement, the Automated Production Control System for the following reasons:

1. The inventory records are a key data base in the APC System; it provides the root record for all part references throughout the system. There is no satisfactory alternative to providing an inventory data base which is integrated (with many other records) in the APC System data base. This file is crucial in design, accessibility and integrity to the APC System.

2. Due to the criticality of inventory transactions in the APC system, sufficient processing capacity must be continually provided to ensure timely processing of the estimated 13,000 transactions per day. NASA/KSC has historically provided only limited processing capacity to the SIMS application. Failure to provide adequate processing capacity in the APC environment

would severely hamper the effectiveness of APC System.

3. There would be no cost savings, since NASA/KSC would have to develop software, and provide mainframe and peripheral processing capacity.

4. GSA requirements to review contractor inventories can be met by the APC System.

(b) AUTOGOSS

The AUTOGOSS system is operated at KSC by the Vehicle Operations Directorate. It is oriented to a task structure, tracing tasks and requirements in SRB assembly operations. It is a work control system currently hampered by inadequate hardware capacity, funding, and technical design.

The system is not an MRP system, in that it does not generate manufacturing orders based upon material requirements. Once tasks are input, it does track their status and produces a schedule (using the given tasks and start and end dates). AUTOGOSS has achieved 20% of its targeted capabilities. Limited funding accounts for some of this shortfall.

Future plans called for adding equipment lists, OMI/task tracking, resource management, configuration management and other modules.

The AUTOGOSS system represents the closest existing system to meeting the needs of an APC System. However, the KDMS project team has suggested that the technical design of AUTOGOSS will not

effectively support the additional modules needed for an APC System. If AUTOGOSS is to be expanded in future KSC operations, it will have to be redeveloped.

Therefore, it is not recommended that AUTOGOSS be used as the automated production control systems for the following reasons:

1. Since AUTOGOSS would have to be redeveloped to incorporate all the features of the APC System described in the business system design section, the development effort would essentially be developing an APC System from scratch. The disadvantages of this approach have been previously discussed in this section.

2. It would not be feasible to utilize AUTOGOSS as a subsystem of the APC System since the development effort to create a subsystem that integrates with the APC System would be greater than modifying the existing subsystems in the proposed package to meet specific requirements.

AUTOGOSS may complement the APC System by being the external module that handles the scheduling of shared contractor resources.

(c) Kennedy Data
Management
System (KDMS)

The Kennedy Data Management System (KDMS) is currently in the requirements definition phase, which is not expected to be completed until the summer of 1981. As of January 1981, its scope had not yet been agreed upon.

It is not contractor specific, but instead focuses on

existing KSC systems. USBI management and personnel were not scheduled for interviews to define their information needs.

It is not possible to say in what way KDMS could be integrated with an APC System, since the KDMS requirements have not yet been defined. We anticipate that the final report will recommend re-developing most existing KSC systems. This effort will be immense, both in cost and time. Given the existing uncertainties in this effort, it is not recommended that KDMS be considered a cost effective and timely alternative to the recommendation that existing software be modified to meet USBI's needs.

(d) Automated
Drawing Release
Systems (ADRS)

ADRS is a system with a completed set of functional requirements as of October 30, 1980.

The system's primary function is to maintain the engineering data base, and to manage engineering changes applied to that data base. It is intended to interface with NASA's SCIT and CMA systems - which provide status accounting and change assurance of ECNs to NASA. Additionally, ADRS will provide to ACMS the "as designed" bill of material in order for ACMS to be able to provide the delta listings (i.e., "as built" versus "as designed"). Thus, ADRS is an important function to the APC System.

Rath and Strong, the recommended software vendor, have estimated three man-months of effort to modify their existing system

to incorporate the features necessary to produce the reports similar to those outlined in Section 3.2 of the ADRS functional requirements document.* It is therefore recommended that many of the ADRS functions be integrated within the APC System package in so far as joint requirements of the APC System and NASA reporting are met. However, two additional factors must be considered. First, NASA has extremely stringent requirements for configuration and documentation management. An APC System is merely a shop environment "tool" that does not require much of the massive detail and audit trail capabilities that ADRS (and ACMS) could provide.

Second, the total installation of the APC System is not scheduled until the end of 1983 (or beginning 1984). It would appear that this time frame would not be satisfactory to meet the short-term needs of NASA or USBI. As a result, consideration should be given to treat ADRS and the APC System as two separate systems (at least for the time being) until a preliminary system design can further identify timing requirements and opportunities for possible integration/interface.

(e) Automated
Configuration
Management
Systems: (ACMS)

ACMS tracks part activity history (e.g., installations, removals) and provides a record for the installation of each part

(*) United Space Boosters, Inc., "Functional Requirements for the Automated Documentation Release System (ADRS)", October 30, 1980.

in a SRB (i.e., "as built" configuration). Using the "as designed" configuration, it produces a "delta" listing showing all discrepancies between the "as built" versus "as designed".

The system has recently entered production status. However, consideration is being given to redesigning the system to integrate it with ADRS. This will eliminate the tedious process of extracting an "as designed" configuration from the NASA/DRS system.

ACMS also performs a limited inventory function, keeping track of receipts, installations, and removals.

The system has significant value in the NASA/USBI SRB production environment due to its capability to provide a history for each part and also the "delta" listing of variances between the "as designed" configuration and the "as built" configuration.

Therefore, it is recommended that modifications to the APC System include incorporating, but in the short term, not replacing the capabilities of ACMS for the following reasons:

1. Since ACMS would be redeveloped to be integrated with ADRS, the cost of incorporating ACMS functions in the APC System should not represent a cost above the cost of redeveloping ACMS.
2. The ACMS data base should be integrated into the APC System data base to facilitate producing the "delta" listing. This approach eliminates problems associated with interfacing two systems on different computers should ACMS be redeveloped separately.

(f) Integrated Parts
Status System
(IPSS)

IPSS was reviewed for its potential to be the APC System for USBI. We do not recommend its use for that purpose for the following reasons:

1. It is currently in a development phase with completion not expected until late 1982. It would be difficult to begin modification of the package to meet USBI needs until the IPSS package has accomplished some degree of completion.

2. IPSS is not MRP driven, but is work driven. This approach was due to the many changes the external tank engineering data base is experiencing. Also, there are no plans to stock subassembly inventory levels, or to purchase/manufacture/refurbish in economic lots.

3. The system does not accommodate automatic back-scheduling to determine an activity start-date.

4. IPSS does not accommodate labor and tools capacity planning.

5. Complete user documentation and overall training programs have not been developed.

6. IPSS does not report the status of critical parts at vendors.

(g) Material Control
System (MCS)

The MCS is primarily a data base which records the inventory status of all flight hardware. Reports generated include shortage

lists. The system resides in Huntsville and the data from KSC is mailed to Huntsville.

The system is not sophisticated enough to perform as an APC function. It would not be desirable to utilize this system as the Inventory Control System for the APC System, since the APC System requires inventory data to be integrated into the data base. Thus, this system will be replaced by the APC System.

(h) Drawing Release
System (DRS)

The DRS system is operated and maintained by USBI/MSFC. The system's primary purpose is to store the engineering data base and subsequent generation breakdown. It is our understanding that this system will be phased out when NASA/MSFC relinquishes the SRB design responsibility.

We do not recommend its use in the APC System since it will be functionally replaced by the integrated ADRS function.

(i) Project Oriented
Management
Information
System (PROMIS)

PROMIS is used by USBI to do resource and milestone planning at the master scheduling level through the use of PERT or critical path algorithms. Since this module of the master scheduling subsystem is scheduled for implementation late in the project, we recommend that PROMIS be retained in a mode external to the automated production control system. It could be replaced at a

later date by a more sophisticated resource planning and operations budgeting system.

(j) Booster
Simulation Model
(BOSIM)

The BOSIM system is a shuttle program modeling technique for SRB production requirements, used to approximate the costs of the full program and to evaluate production policy decisions (e.g., spares impact, attrition forecasting).

There is no functional overlap between BOSIM and the APC System; thus neither replaces or can replace the other.

(k) Performance
Monitoring
System (PMS)

The PMS system is intended to evaluate contractor work. It compares the value of work scheduled with the value of work accomplished. It is not being used to measure USBI during the design development, test and evaluation phase.

The operations budgeting tracking techniques in the automated production control system will be an upgraded version of the PMS which could serve USBI's production management as well as NASA's supervisory requirements. This subsystem will not become operational until late 1983. Consequently, the PMS system could be appropriate until that time.

(1) Standard Change
Integration And
Tracking System
(SCIT)

SCIT tracks engineering change notices from conception to approval by the board. It then passes this information to the Configuration Management Accounting system (CMA).

This function was included in the Change Status System (CSS) of ADRS and will be provided in the APC system. Thus the SCIT will no longer be necessary when the ADRS features of APC System becomes operational.

(m) Change Management
Accounting (CMA)

The CMA system tracks approved engineering change notices through actual incorporation. These functional requirements were noted as part of the Change Status System of ADRS, which could be incorporated in the APC System.

Thus, the CMA system will no longer be required when the ADRS features of the APC System become operational.

(n) Computer Assisted
Drawing (CAD)

The CAD system is a software package used to facilitate origination and maintenance of engineering drawings. The CAD system will still be required to produce the necessary graphics, and neither duplicates or is duplicated by any function in the APC System.

(o) Provisioning System

This system defines the maintenance/support requirements to engineering drawings and advises what to buy or not to buy to support an item. Its end purpose will be to develop inventory level policy, specifically safety stock levels.

It does not appear to functionally duplicate or be duplicated by the APC system. It may be used to determine inventory policy criteria in the APC System.

(p) Central Data
Processing
System (CDS)

This system is used by KSC to satisfy NASA requirements for identification of problem areas through capturing problem reports. This KSC requirement could be met by feeding problem reports into it from the APC system.

(q) Problem Reporting
And Corrective
Action System
(PRACA)

The USBI Problem Reporting System receives and stores problem reports encountered during USBI operations in the SRB assembly process.

It is recommended that this system continue to function with an interface with the APC System to provide it with an administrative record of problem reports. The APC System will capture problem reports on the shop floor.

At a later time, it may be feasible to incorporate the administration of problem reporting into the APC System.

(r) IBM System 6

This hardware is used for word processing associated with generating work authorization documents (e.g., OMIs, BOSs). It neither duplicates or is duplicated by any function in the APC System. It would be desirable for the APC system to be able to automatically extract routing resource requirements from the WADs. The feasibility of this function should be examined in the Detail Design Phase.

(s) Automatic
Check-Out (ACO)

This system is used by NASA and USBI for automatic check-out of shuttle functions and processing of sensor calibration telemetry. It neither duplicates or is duplicated by any APC function.

CONCEPTUAL
INTEGRATION

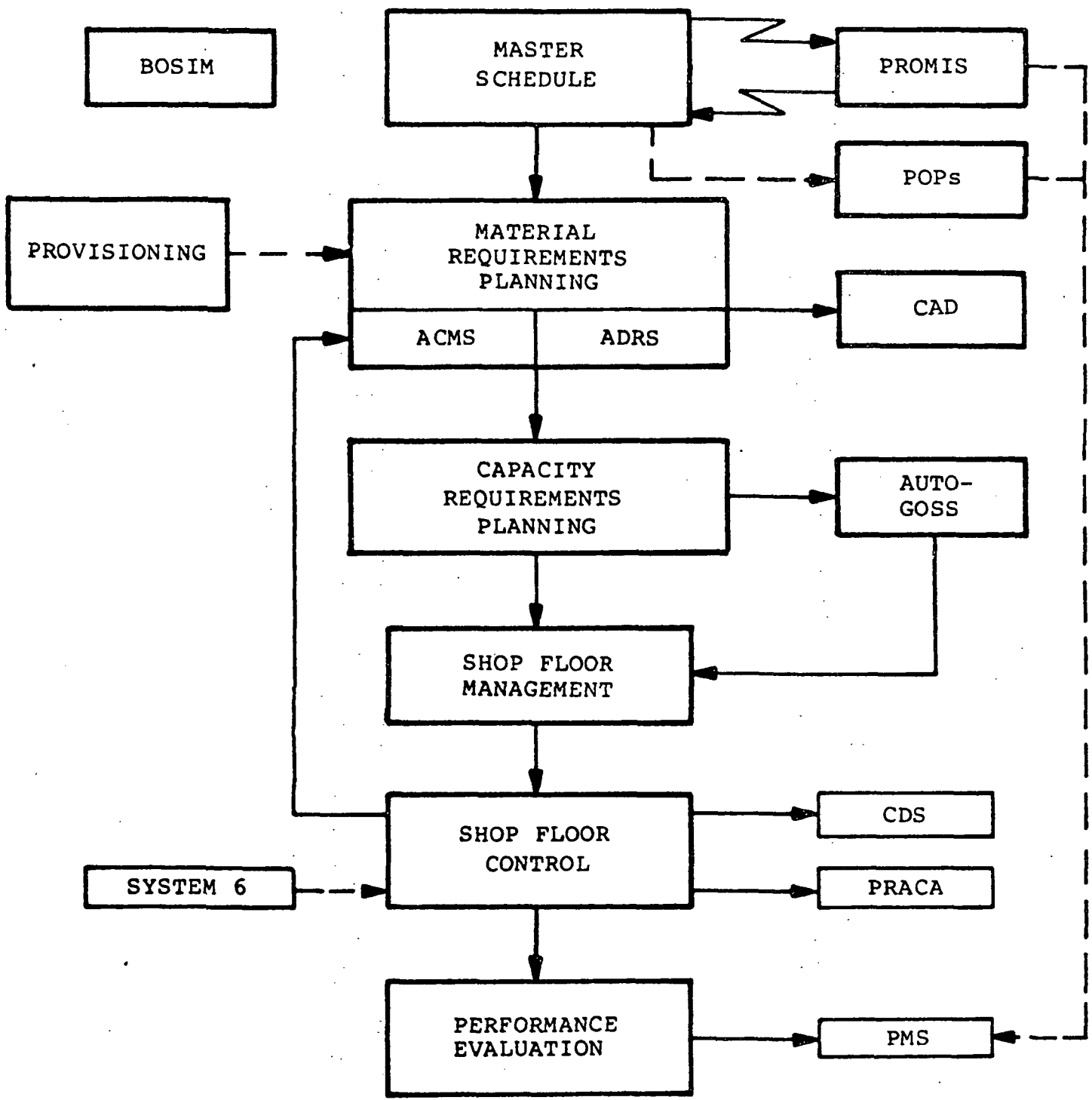
Figure V-7 depicts the conceptual integration of the automated production control system with existing NASA/USBI systems. This conceptual integration is explained below by system:

1. BOSIM. There is no actual integration or interface of the APC system with BOSIM. However, it is recognized that both systems are separately concerned with estimated costs and impacts of production policy on the launch schedule.
2. PROMIS. PROMIS could receive the major assembly gross requirements file from the APC System, and process it against

Figure V-7

Automated Production Control System

Conceptual Integration



the summary resource requirements file to produce resource and milestone planning reports to the master scheduling subsystem.

3. Provisioning. While there may not be a direct interface between the APC System and the Provisioning system, the Provisioning system can assist in making inventory policy decisions (e.g., safety stock) that can be input to the inventory policy file of the materials planning requirements subsystem.

4. ADRS. ADRS could be functionally integrated into the APC System to the extent required by the APC System. The engineering data base could be maintained within the bill of materials module which could maintain both the engineering and manufacturing bills of material. The bill of materials module could track current ECN status. A subsystem could be developed to track milestones (e.g., authorization points, implementation activities) of pending/approved ECNs, routing changes, problem reports, and other items requiring administrative accounting.

5. CAD. The engineering data base in the APC System will provide parts lists numbers to the computer-aided drawing function.

6. AUTOGOSS. Manufacturing resource requirements pertaining to contractor-shared GSE equipment could be passed to AUTOGOSS, if KSC were to agree to use AUTOGOSS for the purpose of scheduling shared GSE equipment. Upon scheduling the equipment, AUTOGOSS would send the scheduled or nonscheduled requirement back to the APC System.

7. IBM System 6. While there may be no direct interface

between the word processing equipment responsible for text maintenance to the work authorization documents, these WADs are needed on the shop floor at the appropriate times. Prior to these requirements, the required WADs will be identified, printed, and distributed to the operations control/dispatch areas.

8. ACMS. ACMS could be integrated into the APC System data base (to the extent required by the APC system), as a replenishment record for an assembly linked to the requirement record (explicit pegging) for a component part. Additionally, shop order routing could be linked to the replenishment record, which would facilitate tracking of installations, removals, and problem reports. It could produce the material "delta" listing by comparing the requirement record generated by the bill of material with the replenishment record of the part actually installed.

9. CDS/PRACA. Problem reports captured in the shop floor operations subsystem by the APC System will be interfaced to the KSC/CDS system and the USBI/PRACA system. No return interface is required.

10. Performance Monitoring System (PMS). Data required by the PMS system will be provided by the APC System performance evaluation subsystem. This will be compared with data provided by POPs and PROMIS to develop performance reports.