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TEAM

Technologies Enabling Agile Manufacturing

Shop Floor Control Requirements Guide

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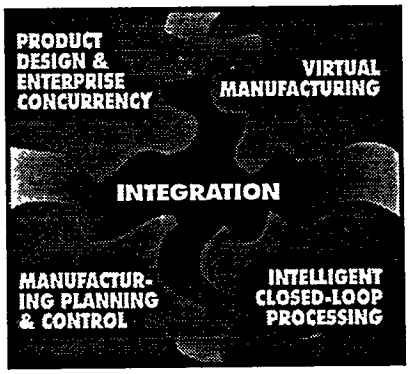

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TECHNOLOGIES ENABLING AGILE MANUFACTURING
Manufacturing Planning & Control
Shop Floor Control

REQUIREMENTS DEFINITION

1. Overview

TEAM will create a shop floor control system (SFC) to link the pre-production planning to shop floor execution. SFC must meet the requirements of a multi-facility corporation, where control must be maintained between co-located facilities down to individual workstations within each facility. SFC must also meet the requirements of a small corporation, where there may only be one small facility. A hierarchical architecture is required to meet these diverse needs. The hierarchy contains the following levels: Enterprise, Factory, Cell, Station, and Equipment. SFC is focused on the top three levels.

Each level of the hierarchy is divided into three basic functions: Scheduler, Dispatcher, and Monitor. The requirements of each function depend on the hierarchical level in which it is to be used. For example, the scheduler at the Enterprise level must allocate production to individual factories and assign due-dates; the scheduler at the Cell level must provide detailed start and stop times of individual operations.

Finally, the system shall have the following features: distributed and open-architecture. Open architecture software is required in order that the appropriate technology be used at each level of the SFC hierarchy, and even at different instances within the same hierarchical level (for example, Factory A uses discrete-event simulation scheduling software, and Factory B uses an optimization-based scheduler). A distributed implementation is required to reduce the computational burden of the overall system, and allow for localized control. A distributed, open-architecture implementation will also require standards for communication between hierarchical levels.

2. System Architecture

The shop floor control system architecture shall be hierarchical, where the hierarchical levels resemble those defined by the International Standards Organization (ISO): Enterprise, Factory, Cell, Station, and Equipment. Shop floor control is primarily concerned with the top three levels. A brief description of each level is provided below.

Enterprise Level: Responsible for the achievement of the mission of the enterprise, and its planning horizon is measured in years and months. Accepts new-product orders from Macro Planning, existing-product orders from order-entry system, and make-to-stock orders to meet

forecasted future demand. Allocates production tasks to factories; coordinates due-dates among factories. Suggested technology: MRP I, MRP II, Capacity-Constrained Resource Planning.

Factory Level: Responsible for the implementation of the enterprise functions and the reporting of status information to the enterprise level. Decides inter-cell routing, resource allocation, and lot sizes using finite-capacity techniques. Suggested technology: Discrete-Event Simulation, Optimization.

Cell Level: Responsible for the sequencing and dispatching of jobs through various stations. The time horizon is typical days to a few weeks. Suggested technology: Optimization, Control Theory.

Each SFC hierarchical level shall have the following components: Scheduler, Dispatcher, and Monitor.

Scheduler: Accepts production requirements from a higher hierarchy level (or from an order-entry system if at the Enterprise level), and develop a schedule which determines the precise use of the resources at the next level (e.g., Factory scheduler schedules/coordinates the cells). Performs capacity analysis to determine if production requirements can be met. Feasible schedule released to the Dispatcher.

Dispatcher: Takes inputs of schedule from Scheduler, and status from Monitor, and tries to meet the schedule as best as possible. The dispatcher is especially critical at the factory and cell levels, where real-time decisions must be made when machines break down, components run out, raw material deliveries are late, or quality problems arise.

Monitor: Collect status information from the monitor functions at the next lower level, filters the status information, and sends relevant information to the Dispatcher at the same level and the Monitor at the next higher level.

3. SFC Requirements

3.1 Enterprise Level
3.1.1 Scheduler
3.1.2 Dispatcher
3.1.3 Monitor

3.2 Factory Level
3.2.1 Scheduler
3.2.2 Dispatcher
3.2.3 Monitor

3.3 Cell Level
3.3.1 Scheduler
3.3.2 Dispatcher
3.3.3 Monitor

4. Shop Floor Control Functional Diagram

The Shop Floor Control Functional diagram on the following page illustrates the main functions of Shop Floor Control and the relationships between major modules within Shop Floor Control, and the relationships with other components in the TEAM Model.

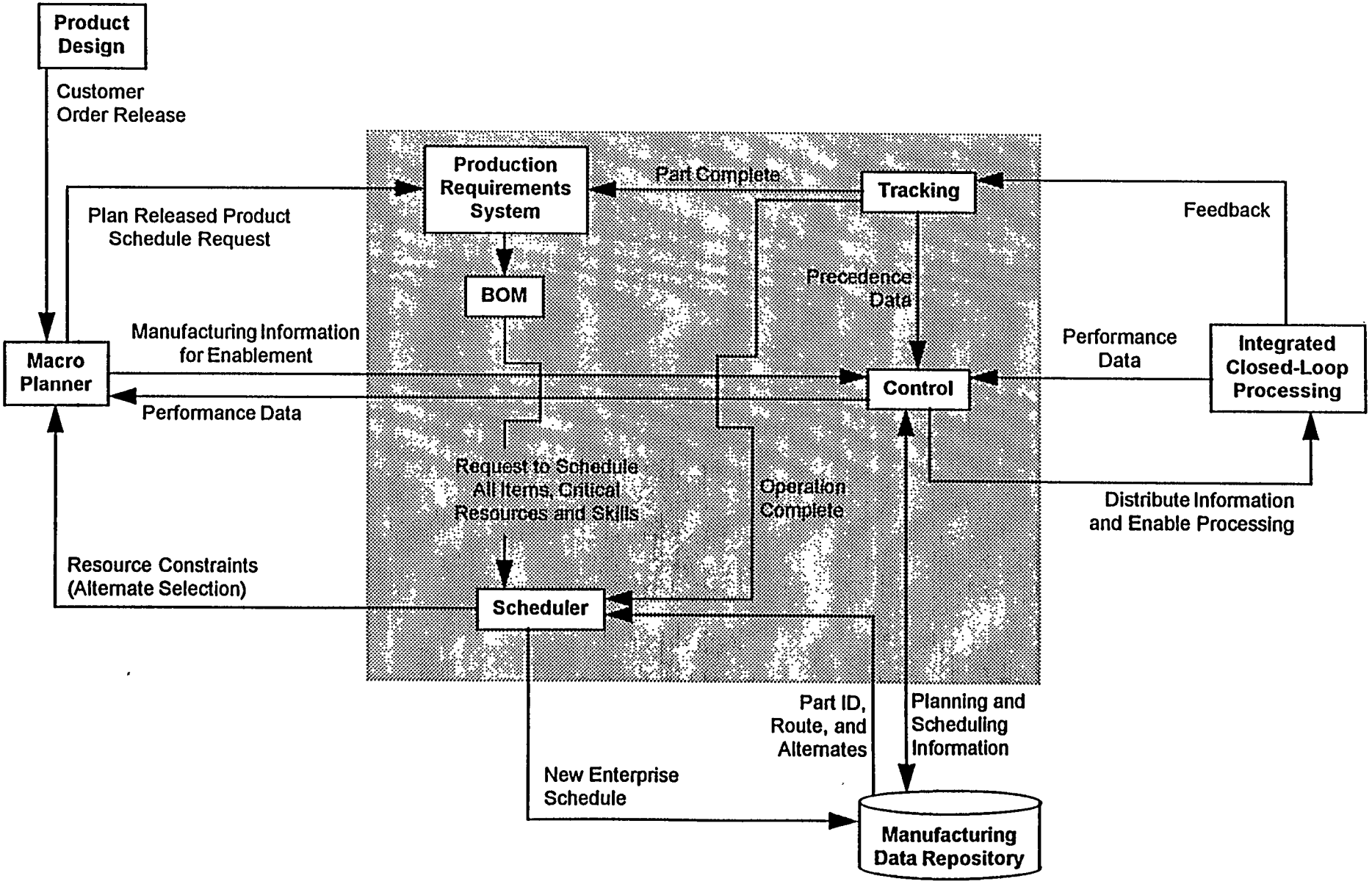
The Production Requirements System administers the demands, delivery dates and completions for the enterprise.

The Bill of Material (BOM) module explodes requirements data to the manufactured articles, raw materials and supplies required for production. When coupled with the Macro Planner data the result is the structure required to construct the production network for use by the Scheduler.

The Scheduler uses the Production Requirements information and the BOM/Planner data and constructs the detailed schedules for each resource for each product, route and operation.

As the manufacturing plan for each article is executed the Tracking and Control modules preform the tasks of tracking the article and managing the data collection for each article. Simultaneously the Control Module administers preplanned control functions based on the data collected and the articles status as determined by the Tracking Module.

Shop Floor Control Functional Diagram



From the draft functional requirements that follow a suitable complement are to be chosen based on the industry driven requirements. the requirement specify the functions and capabilities to be included in the TEAM Shop Floor Control and the TEAM Scheduler capabilities.

These requirements have been extracted from requirements documents previously used by Martin Marietta Energy Systems.

1 Shop Floor Control Functional Specifications

1.1 System Mechanics

1.1.1 Software shall support the data structures such that a facility or plant shall contain responsibility areas and those responsibility areas shall contain resources and other items.

1.1.2 Software shall support the data structures such that grouped resources can be constituted by one or many resources; the capability unit so specified shall be listed by the job (part, specimen, sample) item and the operation required combination.

1.1.3 Software shall provide for importing data routinely or on demand.

1.1.3.1 Software shall provide a mechanism that will allow all product definition data including bill of material data required by the software to be imported by file transfer and/or transaction updating.

1.1.3.2 Software shall provide a mechanism that will allow all process definition data including routing data required by the software to be imported by file transfer and/or transaction updating.

1.1.3.3 Software shall provide a mechanism that will allow all schedule data required by the software to be imported by file transfer and/or transaction updating.

1.1.3.4 Software shall provide a mechanism that will allow all resource and item data required by the software to be imported by file transfer and/or transaction updating.

1.1.3.4.1 Software shall provide for importing equipment definition data.

1.1.3.4.2 Software shall provide for importing tooling and gaging definition data.

1.1.3.4.3 Software shall provide for importing personnel definition data.

1.1.3.5 Software shall provide a mechanism that will allow systems support data, such as calendars, required by the software to be imported by file transfer and/or transaction updating.

1.1.4 Software shall provide for exporting data routinely or on demand. The contents for such an exported file shall be definable by the user.

1.1.4.1 Software shall provide for export of all productive and non-productive time.

1.1.4.2 Software shall provide for export of job status data.

1.1.4.3 Software shall provide for export of utilization and status data for items and resources.

1.1.5 Seller shall enumerate transaction types provided to control normal manufactured items through their routing.

1.1.6 Software shall provide for transaction and activity logs.

1.1.6.1 Software shall provide a mechanism to construct an activity log for any item or manufactured item serial number.

1.1.6.2 Software shall provide a mechanism to interrogate the transaction log and/or the activity log.

1.1.7 Software shall provide for maintenance of data required to operate and use the system.

1.1.7.1 Software shall provide a mechanism to maintain the integrity of data entered into the system.

1.1.7.2 Software shall provide a mechanism to maintain and create all system required data and retained data by on line transactions.

1.1.7.3 Software shall provide a mechanism to allow archival of all system data for a manufactured item serial number, serialized items, and all associated process data by User specified criteria.

1.1.7.4 Software shall provide a mechanism to retrieve from archived data for any item or set of items.

1.1.8 Software shall provide a mechanism to create, control, and monitor transactions.

1.1.8.1 Software shall provide a mechanism to create and execute User defined transactions that cause actions in internal and/or external systems.

1.1.8.2 Software shall enable transactions from external systems to cause the appropriate action/actions to be executed in the software.

1.1.9 Software shall provide a mechanism to identify data items as mandatory or discretionary when collecting data. The selection criteria shall be based on either a manufacturing item serial number or lot number or a manufacturing item type or operation or manufacturing item serial number status. Selection criteria shall provide for combination of the aforementioned data types.

1.1.9.1 Process data collection controlled by the criteria.

1.1.9.2 Operator data collection controlled by the criteria, including time collection.

1.1.9.3 Manufacturing item serial data collection controlled by the criteria.

1.1.9.4 Resource data collection controlled by the criteria.

1.1.10 Software shall provide a mechanism to identify data items as mandatory or discretionary when collecting resource data. The selection criteria shall be based on a resource serial, resource type or item serial, item type.

1.1.10.1 Operator data collection controlled by the criteria, including time collection.

1.1.10.2 Resource data collection controlled by the criteria.

1.1.11 Software shall provide a mechanism to generate electronic mail messages from operational events.

1.1.12 Software shall provide a mechanism to construct and retain/store/use standard

and custom queries of system retained data.

1.1.12.1 Software shall provide a mechanism wherein ad hoc queries can be formulated and response directed to terminal(s), local printers, or system printers. Provision shall be made for such queries to be maintained and available for reuse.

1.1.12.2 Software shall provide for queries that continuously update the screen by posting data as changed in the selected area or areas. The contents of such queries shall be definable by the user.

1.1.12.3 Software shall provide a standard set of queries and reports.

1.1.12.4 Software shall provide a mechanism to access and display electronic procedures.

1.1.13 Software shall provide a transparent data path/interface to a standard statistical application system such as SAS.

1.1.14 Software shall provide an application development tool that will enable the User to interface intelligent devices to the system for display, transfer, and/or collection of data.

1.2 Job Entry, Schedule Maintenance And Control

1.2.1 Software shall provide for the receipt of a detail schedule periodically from an external system as a file containing the jobs required for execution on the shop floor.

1.2.1.1 The file shall contain the following data items: manufacturing item identifier, routing step, quantity required, primary resource and quantity, support resource and quantity, a maximum of seven auxiliary resources and quantity. For jobs requiring a setup the file shall contain additionally a setup required indicator, setup resource and quantity, setup time required, planned start date and time, and planned completion date and time.

1.2.2 Software shall provide for insertion of a job of either a single routing step or multiple single routing steps and a quantity required for a resource.

1.2.2.1 A log of all manually entered jobs shall be kept by the system.

1.2.2.2 Insertion of a job into the queue shall not cause the data for other jobs in the queue to be altered.

1.2.3 Software shall provide for insertion, modification or deletion of the following entries in the job queue: resource required, quantity required and estimated time. Manufacturing item identifier and scheduled start and completion times shall not be changed.

1.2.3.1 The priority sequence from the original detail schedule shall be preserved.

1.2.4 Software shall provide a resource activity queue for the purpose of indicating periods of resource unavailability.

1.2.4.1 Such activities shall be identified by the resource identity, planned start time of unavailability, planned ending time of unavailability, and activity description.

1.2.5 Software shall enable a joint view of the job queue and the resource activity queue.

1.2.5.1 A view from any level of resource shall be provided.

1.2.5.2 A view from a responsibility area shall be provided.

1.2.5.3 A view for any manufactured item identifier shall be provided.

1.2.5.4 A view by start time, horizon or completion time shall be provided.

1.2.5.5 A view by the next n (specified number) of jobs in the queue shall be provided.

1.2.5.6 A view combining any and all of the items above shall be provided.

1.3 Work Control & Execution

1.3.1 Software shall provide a mechanism for selection of dispatched job.

1.3.1.1 Provide automatic selection for a resource based on the position/priority in the queue.

1.3.1.2 Provide manual selection.

1.3.2 Software shall provide a mechanism to select a job that has not been dispatched.

1.3.2.1 Provide automatic selection for a resource based on the position/priority in the queue at User's discretion.

1.3.2.2 Provide a mechanism such that manual job selection is based on authorized person/supervisor.

1.3.3 Software shall provide for creation and maintenance of an available (at work) manpower roster for each responsibility area.

1.3.3.1 Provide for use of a training inventory for each operator.

1.3.3.2 Provide for cross responsibility area inquiry of available training for all operators and their present status.

1.3.4 Software shall provide mechanism for assigning manpower to the selected job and or resource.

1.3.4.1 An operator or group of operators (crew) is assigned a job at a resource.

1.3.4.2 An operator or group of operators (crew) shall be re-assignable prior to completion of a job.

1.3.4.3 The area supervisor will have a mechanism to monitor and report the operator status. The mechanism will inform the supervisor that the job is complete. The mechanism shall indicate that the operator is available if no other jobs are dispatched for that resource.

1.3.5 Software shall provide a mechanism to control the execution of the job step.

1.3.5.1 Provide for execution of a job step that requires no specific certification.

1.3.5.2 Provide for execution of a job step that requires a certified process wherein correct completion of the individual steps constitute certification of the item in that routing step.

1.3.6 Software shall provide for execution of a job step utilizing only a certified resource or item.

1.3.6.1 Provide for execution of a job step that requires a certified operator.

1.3.7 Software shall provide a mechanism to control the execution of the normal routing and routing steps by utilizing plans/procedures which specify the sequence of operations to be performed and the data to be collected. A mechanism shall be provided that enables the plan/procedure to control/monitor the sequence of operations performed such that operations may be optionally sequenced or the sequence can be specified and that data elements may be optionally or mandatorily collected.

1.3.7.1 Provide a mechanism to view or execute a electronically based procedure, containing both text and graphics, via a terminal or from an external computer or controller.

1.3.7.1.1 Provide revision control on the procedure.

1.3.7.1.2 Collect operator time data while executing procedure.

1.3.7.1.3 Collect manufactured item data while executing procedure.

1.3.7.1.4 Establish the next routing step based on the disposition of the manufactured serial number or lot number and the routing logic.

1.3.7.1.5 Collect resource data and/or process data while executing procedure.

1.3.7.2 Provide a mechanism such that on the completion of a job the appropriate job queues and resource and job statuses are updated to reflect the job completion.

1.3.8 Provide for execution of a job without a electronic procedure, and simultaneously allow for collection of data for the routing step.

1.3.8.1 Collect operator time data.

1.3.8.2 Collect manufactured item data.

1.3.8.3 Establish the next routing step based on the disposition of the manufactured serial number or lot number and the routing logic.

1.3.8.4 Collect resource data and/or process data.

1.3.9 Software shall provide a mechanism that allows for the disposition of the job (transfer batch) by return of the work in process to inventory or delivery to the next resource in the routing.

1.3.10 Software shall provide for initiation/generation of samples or specimens.

1.3.10.1 Generation of a sample/specimen per the electronic procedure for that operation.

1.3.10.2 Manual generation of a sample/specimen per the paper procedure for that routing step.

1.3.10.3 Generation of a sample/specimen per the routing step for that manufacturing item type.

1.3.10.4 Generation of a sample/specimen per the bill of material for that manufacturing item type.

1.3.10.5 Generation of a sample/specimen on an ad hoc basis.

1.3.11 Software shall provide for a mechanism that will enable the maintenance of production statuses.

1.3.11.1 The status of the job at a routing step, where values shall be user defined but will include dispatched, queued, complete, incomplete.

1.3.11.2 The operational status of a manufactured item serial number shall be user defined but will include incomplete, complete, setup, in transit, or available.

1.3.11.3 The quality status of the manufactured item serial number at the routing step shall be user defined but will include reject, deviation requested, non conforming, killed, accepted, certified.

1.3.11.4 A control status indicating the job order status such as

STOPWORK or CANCEL.

1.3.12 Software shall provide a mechanism to enable execution based on collected data for the manufactured item serial number, or sample/specimen disposition or data, or process data.

1.3.12.1 Provide for the situation where one or many manufactured item serial numbers may be represented by one or many sample/specimen results.

1.3.12.2 Provide a mechanism such that subsequent steps in the routing may be marked as executable while awaiting processing results for sample/specimen(s).

1.3.12.3 Provide a mechanism such that none, some or all of the subsequent steps in the routing are executed because of the value of data collected on the manufactured item serial number.

1.3.12.4 Provide for control/status change on the basis of process or product data collected within the routing step.

1.3.13 Software shall provide for execution of routing with exception logic and provide for correctly adjusting logical inventory.

1.3.13.1 Provide authorization by administrative group to move manufactured item serial numbers between routing steps.

1.3.13.2 Provide for first article inspection.

1.3.13.3 Provide for partial feature inspection of any manufacturing item serial number.

1.3.13.4 Provide for definition of rework requirements and control.

1.3.13.4.1 Provide for a standard rework routing for each responsibility area or manufactured item type or routing step.

1.3.13.4.2 Provide for items to be re- queued at a standard point in the routing for each manufactured item type routing step combination.

1.3.13.4.3 Provide for ad hoc rework routing for each manufactured item serial number.

1.3.13.5 Provide for the control of non conforming material.

1.3.13.5.1 Provide for control of material to be processed as non conforming.

1.3.13.5.2 Provide a mechanism for processing of non conforming material candidates pending determination of the conformity or non-conformity.

1.3.13.5.3 Provide a mechanism for initiation of a request for deviation, receipt of a disposition and execution of that requested action.

1.3.13.5.4 Provide for changing the identity of a non conforming manufactured item serial number so that its use in the same form or fit is enabled.

1.3.14 Software shall provide a mechanism to change the manufactured item type of a manufactured item serial number to a different manufactured item type and serial. Such a change shall not destroy traceability to the original manufactured item type and serial along with all of its previous manufacturing history.

1.3.15 Software shall provide for kitting of manufactured item types.

1.3.15.1 Provide for kitting of manufactured items for assembly by bill of material.

1.3.15.2 Provide for kitting of manufactured items by assembly bill of material with specifically identified manufacturing item serial numbers.

1.3.15.3 Provide for kitting of manufactured items that are subsequently separately processed then reunited or assembled.

1.3.15.4 Provide for trial assembly of manufactured items.

1.3.15.5 Provide a mechanism wherein a manufactured item serial that is an assembly may have one or more of its manufactured item serial numbers removed and a different serial number

substituted.

1.3.16 Software shall provide mechanisms to support continuity of operations.

1.3.16.1 Provide for execution of a procedure across the change of shift.

1.3.16.1.1 Identity of operator and times of changeover shall become items of record.

1.3.16.2 Provide a mechanism to facilitate status messages and operational information to be available to the next operator.

1.4 Quality Management

1.4.1 Software shall provide a mechanism to utilize revision control of production related documents by manufactured item serial number to control and document work execution.

1.4.1.1 Software shall provide for revision control for electronic procedures.

1.4.1.2 Software shall provide for collection of procedure and revision identity for paper (non-electronic) procedures.

1.4.2 Software shall provide a mechanism to utilize revision control of production related documents by date and time to control and document work execution.

1.4.2.1 Software shall provide for revision control for electronic documents.

1.4.2.2 Software shall provide for collection of procedure and revision identity for paper (non-electronic) documents.

1.4.3 Software shall provide a mechanism to cross reference and connect manufactured item serial number, process, and operator data for a given job.

1.4.4 Software shall provide a mechanism for a sample to represent multiple manufactured items or a lot of manufactured items.

1.4.5 Software shall provide for each end or shippable manufacturing item type an as-planned and an as-built configuration.

1.4.6 Software shall provide for control and reporting the use of certified resources and/ or operators for routing steps.

1.4.6.1 Control and report operations performed by certified resource.

1.4.6.2 Control and report operations certified by performing an approved procedure.

1.4.6.3 Control and report operations performed by certified operator.

1.4.7 Software shall provide for acceptability limits for process and manufactured item data.

1.4.7.1 Verify a single value or series of values against an acceptability limit

1.4.7.2 Verify a value computed from a set of values against an acceptability limit

1.4.7.3 Verify a series of values against a specified range

1.4.7.4 Verify a result of a User defined algorithm against an acceptability range.

1.4.8 Software shall provide a mechanism to change the manufacturing item serial statuses based on any out of limit condition.

1.4.9 Software shall provide for administration of the User sampling plan by providing the functions enumerated below.

1.4.9.1 Software shall provide for the administration of as required or random routing steps and/or abnormal routing execution

1.4.9.2 Software shall provide a mechanism for requiring mandatory subsets or steps of a procedure to be executed by manufactured item serial number or manufactured item type.

1.4.9.3 Software shall provide a mechanism to exempt manufactured item serial numbers from sampling.

1.4.9.4 Software shall provide a mechanism for a manufactured item serial number to be exempt from inspection (free ride).

1.4.10 Software shall provide standard statistical quality control charts for the operator or combination of operators, resource or combination of resources of a quality attribute for a manufactured item type.

1.5 Queue Management

1.5.1 Software shall provide for the continuous re-sequencing of jobs for a resource or responsibility area.

1.5.1.1 Each responsibility area or resource shall have a suitable sequencing and re-sequencing algorithm identified. The methods utilized shall be based on parameters of the jobs in the area covered.

1.5.1.1.1 Original position in priority list shall be one parameter.

1.5.1.1.2 Available inventory count shall be one parameter.

1.5.1.1.3 Job start time and date or job completion time and date shall be parameters.

1.5.1.1.4 Job duration shall be one parameter.

1.5.1.1.5 Externally supplied numerical priority shall be one parameter.

1.5.1.1.6 Available resource or item shall be one parameter.

1.5.1.1.7 Manufacturing item type shall be one parameter.

1.5.1.1.8 Job status values or attributes shall be one parameter.

1.5.1.1.9 Special priority routing steps shall be one parameter.

1.5.1.1.10 Due date of the mother manufactured item for a sample/specimen shall be one parameter.

1.5.1.1.11 Routing step/routing step description shall be one parameter.

1.5.2 Software shall provide a mechanism to explode the inventory at an routing step or explode the inventory of a manufactured item type at an routing step to reveal the manufactured serial numbers, their associated statuses and

location.

1.5.3 Software shall provide a mechanism to selectively disable the re-sequencing mechanism provided.

1.5.4 Software shall provide a mechanism to create a service request (job) at a resource to be performed at another resource.

1.5.5 Software shall provide a mechanism to automatically delete completed jobs from the resource queue and log the completion to a job completion log.

1.5.6 Software shall provide a mechanism for manually changing the operational status of a job in a resource queue.

1.6 Time Collection

1.6.1 Software shall provide for time (effort) collection of an operator per MIL STD 1567A.

1.6.1.1 Collect set up time for a routing step.

1.6.1.2 Collect operation (productive) time for a manufactured item serial number.

1.6.1.3 Collect tear down time for the routing step.

1.6.1.4 Collect non-productive.time against a set of User defined criteria/codes.

1.6.1.4.1 Software shall provide for at least 1000 such codes.

1.6.2 Software shall provide for time collection for utilization of a resource.

1.6.3 Software shall provide a mechanism activated at User discretion to account for all of the time for a resource.

1.6.3.1 Collect set up time for an routing step.

1.6.3.2 Collect operation (process) time for a manufactured item serial number.

1.6.3.3 Collect tear down time for the routing step.

1.6.3.4 Collect non-productive time against a set of User defined criteria/codes.

1.6.3.5 Provide for capturing un-available and idle time.

1.6.3.6 Provide for capturing maintenance time as up time, repair time, preventative maintenance time, predictive maintenance time, and out of service time.

1.6.3.7 Provide for collecting time required for certification of a resource.

1.6.4 Software shall provide a mechanism activated at the User discretion to collect time for a manufactured item serial number.

1.6.4.1 Provide for collecting dormant time.

1.6.4.2 Provide for collecting time when consuming a resource.

1.6.4.3 Provide for collecting transit time.

1.6.5 Software shall provide a mechanism activated at the User discretion to collect entities on items.

1.6.5.1 Provide a mechanism to collect number of uses for a resource or item.

1.6.5.2 Provide the availability status on the same basis as the availability status for a resource.

Allocations are to be performed by User defined criteria.

1.6.6 Software shall provide for collection of productive and non-productive time.

1.6.7 Software shall provide for collective time transactions for a defined group or crew.

1.7 Software shall provide for collecting attendance.

1.7.1 Software shall provide for recording arrival and departure times for hourly, exempt and nonexempt employees.

1.7.1.1 Use of the feature shall be selected by responsibility area and

payroll.

1.7.1.2 Use of the feature shall be selected by employee identity number.

1.7.2 Software shall provide for assignment of an operator to a responsibility area, shift and supervisor.

1.7.3 Software shall provide for temporary assignment of an operator to another responsibility area, shift and supervisor.

1.7.4 Software shall provide a mechanism for an authorized person to enable and authorize an operator to do a job on other than their standard shift.

1.8 Tracking of Resources

1.8.1 Software shall provide a mechanism to track status of resources as to repair, use and certification.

1.8.1.1 Track status of a resource with respect to its utilization, that is in use, idle, set up.

1.8.1.2 Track status of a resource with respect to its maintenance status, that is down, being repaired, up or preventative.

1.8.1.3 Track status of a resource with respect to its operation status, that is what operation or set up is presently on the resource.

1.8.1.4 Track status of the certification status of a resource.

1.8.2 Software shall provide for the maintenance of a schedule of events for a resource.

1.9 Tracking of Items

1.9.1 Software shall provide for the tracking of serialized items and manufactured item serial numbers.

1.9.2 Software shall provide for the tracking of raw material lots as they are consumed in the manufacturing process.

1.9.3 Software shall provide for the tracking of combination of items and/or lots to

produce a new item and/or lot.

1.9.4 Software shall provide for the tracking of by products as produced in the manufacturing process.

1.9.5 Software shall provide for inventory (physical) location of the manufactured item serial number while the manufactured item serial number is in process inventory.

1.9.6 Software shall provide a mechanism to collect data on the material balance of items at an routing step.

1.10 Notification and Reporting

1.10.1 Software shall provide a mechanism activated at User's discretion to report manpower utilization.

1.10.1.1 Report set up time for an routing step.

1.10.1.2 Report operation (productive) time for a manufactured item serial number.

1.10.1.3 Report tear down time for the routing step.

1.10.1.4 Report non-productive time against a set of User defined criteria.

1.10.2 Software shall provide a mechanism activated at User's discretion to report all of the time for a resource or group of resources.

1.10.2.1 Report set up time for an routing step.

1.10.2.2 Report operation (productive) time for a manufactured item serial number.

1.10.2.3 Report tear down time for the routing step.

1.10.2.4 Report non-productive time against a set of User defined criteria.

1.10.2.5 Provide for reporting available and idle time.

1.10.2.6 Provide for reporting maintenance time as up time, repair

time, preventative maintenance time, predictive maintenance time, and out of service time.

1.10.2.7 Provide for reporting time used for resource certification.

1.10.3 Software shall provide a mechanism activated at the User's discretion to report time for a manufactured item serial number.

1.10.3.1 Provide for reporting dormant time.

1.10.3.2 Provide for reporting time when consuming a resource.

1.10.3.3 Provide for reporting transit time.

1.10.4 Software shall provide a mechanism activated at the User discretion to report data collected for entities on items.

1.10.4.1 Provide a mechanism to report number of uses for a resource or item.

1.10.4.2 Report the availability status on the same basis as the availability status for a resource.

1.10.5 Software shall provide notification of expiration of item or resource certification.

1.10.5.1 Software shall provide a lead time specified warning message with lead time specified by resource or item identification or responsibility area.

1.10.5.2 Software shall provide for notification by electronic mail.

Requirements Definition for Detailed Scheduling

I. Scheduling Function Shall Perform and Provide the Following:

a. Detail schedules that are feasible, constrained by equipment part and material availability, manpower, and other specified resources. Such schedules shall be generated for each specified resource on a time-line basis.

b. System calculated or otherwise determined, variable as appropriate, batch or campaign sizes, optionally fixed or with a specified range.

c. A feature to adjust schedules based on the requirement to level labor requirements.

d. Generation of master schedules for subassemblies and parts based on final product requirements, given product bill of material structure.

e. Provide for a variable specified yield at each operation.

f. Parts that are supplied for an assembly operation are scheduled in such a manner that a reasonable match of inventory is maintained, i.e., synchronization of inventory.

g. Final product schedules for inventory production, periodic production and nonrecurring requirements shall be accommodated.

h. Scheduling capability to recognize the combining (assembly) and splitting of parts (explosion). Split and hold part until split-off item(s) are processed - logic shall be provided.

i. Scheduling shall accommodate the re-identification of parts at any operation including the operations of assembly and explosion.

j. Sufficient scheduling diagnostics (not merely computer or data syntax errors) to allow identification of typical problems like resource shortfalls or components deliveries.

k. A change control capability to give effective date of change for alternative parts in an assembly and maintain the option of using all previously generated parts shall be allowed.

l. Master schedule shall be developed from final product schedule and Bill of Material (BOM). Temporal schedules shall be generated for all parts from lead days for processes. Requirements by day are developed and reported.

m. Alternative resources for any process with differing time standards can be specified.

n. System shall provide the ability for use of a release date for the scheduling of an order.

o. System shall allow identification of sub-calendars for equipment and operations so that identified operations will be done on identified days. Other mechanisms for accomplishment are acceptable.

p. System shall provide for variable and fixed lot sizes,

II. Control Function Shall Perform and Provide the Following:

a. System shall enable the user to specify the mode of operation, i.e., to emphasize due date, work in progress reduction or manpower leveling to the extent that they are not mutually exclusive.

b. System shall provide all standard performance measures of scheduling proclivity. At a minimum, late work, work in progress, schedule performance, and resource utilization shall be monitored.

c. System performance shall be insensitive to normal imprecision and variability of estimated times, yields, and durations of specified parts.

d. System shall provide for comparison and adjustment for actual progress against the detail schedule. Feedback period shall be variable as required by user.

e. Changes to an order or schedule shall be allowed and scheduled at any time or stage of production.

III. Modeling Function Shall Perform and Provide the Following:

a. System shall provide capacity planning for multiple resources. Each resource relationship shall be specified as well as an alternative.

b. System shall allow for containers that travel with a part or parts for limited, specified segments of a routing. Reports on the quantity required and utilization of such containers shall be generated.

c. The number of primary and auxiliary resources required by a operation or process shall not be restricted .

d. Varying and multiple modeling periods and frequency of snapshots.

e. Any set of production data shall be available and sufficient to do a simulation of the manufacturing facility. Such simulations will report part and assembly completions and rates as well as resource utilizations. Systems performance (Work In Process schedule compliance, etc.) will be reported.

f. System shall produce raw material requirements function reports for modeling runs.

g. In general, system shall assist in the evaluations of proposed changes by providing performance measurements. Resource utilization, completion dates, and WIP constitute a minimum requirement.

IV. Materials Resource Planning (MRP) Function Shall Perform and Provide the Following:

a. Raw materials requirements shall be determined and reported.

b. Future known deliveries, procurement lead time, and stock on hand shall be used in determining requirements.

c. Expedite or shortage list shall be generated as appropriate.

d. Reports on the location and quantity of all inventory by assembly, part, or process shall be generated.

e. System shall provide inventory analysis to determine inactive material, excess inventory, and processing durations.

f. System shall provide work in process (WIP) inventory analysis.

g. System shall perform explosion requirements calculation based on BOM.

h. System shall reflect order policy as to fixed, minimum, or maximum lot sizes.

i. System shall enable the coding of parts and assemblies so that production is not planned, i.e., obsolete parts.

j. System shall provide a time-phased display of requirements, planned orders, and open orders by requirement.

l. System shall provide for multiple deliveries of the material from a single purchase order.

m. The system shall allow material to be deleted (returned to vendor), added (found), or re-inventoried (shrinkage).

V. Data Resources and Analysis Shall Perform and Provide the Following:

a. A complete Bill of Material (BOM) shall be generated when requested showing, in indented form, all assemblies, subassemblies, parts, and raw materials, including fractional parts of any.

b. Editing, adding, replacing, or converting for an entire part or assembly shall be allowed.

c. Specification of a part or assembly as a look-alike shall be allowed (same as except logic).

d. A where used listing of the BOM shall be generated for selected parts as required.

e. Each part shall carry at least one cost or cost-like data element in addition to multiple resource requirements.

f. Each operation on the routing shall have a rule assigned lead time with provision for a manual override.

g. An accumulated lead time for all parts shall be reportable via the BOM.

h. The routing data shall be sortable and reportable on each field.

i. The system shall generate a routing for any part at any level in the BOM (snapshot).

j. The system shall provide status information in any order, product, or part by location or type.

k. The system shall provide prices for labor and materials on an indented BOM by product or subset thereof.

VI. General Specifications:

a. The system shall use calendar dates with English messages for all reports .

b. The system shall perform projections that span a time of eight (8) years with the capability of fixing up to 200 days as non-work days.

c. The system shall allow for interfacing existing systems as might be required. Examples would be part status and work in progress monitored by another automated system.

d. System shall require no special Data Base Management or File Management packages not supplied with the system.

e. System shall have interactive capability for editing and reporting.

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