

MILITARY PRODUCTS FROM COMMERCIAL LINES

VOLUME II - MANUFACTURING INFRASTRUCTURE IPT

TRW
Space and Electronics Group
Avionics System Division
One Rancho Carmel
San Diego, California 92128

&

TRW
Automotive Electronics Group
902 South Second Street
Marshall, Illinois 62441

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Materials & Manufacturing Directorate
Air Force Research Laboratory
Air Force Materiel Command
Wright-Patterson Air Force Base, Ohio 45433-7734

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Executive Summary

The United States Air Force has contracted with TRW Avionics and System Division (ASD) to develop the processes and products necessary to produce military products in a commercial manufacturing facility. This project is named Military Products from Commercial Lines (MPCL). A key component of MPCL was the development of a world class Computer Integrated Manufacturing (CIM) system to integrate the military design environment with the commercial manufacturing environment. Under MPCL, a Manufacturing Infrastructure (MI) Integrated Product Team (IPT) was given the responsibility for developing the CIM system. This system was designed to facilitate the production of military electronics on commercial lines. The CIM incorporates the following features.

- Product Design

Computer Aided Design (CAD) tools were integrated with a Product Data Management (PDM) architecture system to enable flow of design data between the design and production centers.

- Design-Driven Production

An information transfer process was developed that allows design data to drive the factory planning and launch process. This system uses CAD files to fully program the factory systems, significantly reducing launch time. All information required to build the product is included in the system.

- Product Quality Modeling

A modeling tool was developed to estimate production quality throughout the design and production life cycle. This tool determines first pass yield, production quality issues and defect levels as delivered to the customer.

- Automatic Product Change Over and Process Mistake Proofing

This function supports fast product change over between military and commercial products and insures the change over is complete and accurate. For example, the system insures that the correct production materials are loaded into the correct operation slots. The system also checks production route, process time limits and limits on the number of times a process may be repeated on a single unit.

- Factory Control

This function includes a common set of applications that provide factory level command, control and reporting functions. “As built” data can be obtained from this system along with configuration data. Tools to change system and factory setup are also included.

- Work Cell Control

The Work Cell Control function controls the production floor, providing production workers with quality and setup information along with system status and process instructions. Each production work cell has a computer that provides the interface point to the line. Bar code scanners and machine control logic are routed through these computers to minimize line wiring and support.

- Centralized Production and Quality Data Model

All factory information is controlled and contained in a single data model. All functions in the factory share this data model including the Work Cell Control and Factory Control.

- Highly Modular and Transferable Information System.

The CIM system is designed using rapid deployment modular design to permit transfer to other sites.

The MI IPT was successful in purchasing, developing, and deploying these capabilities at the TRW Marshall plant. The Marshall Flex 3 line is currently equipped with the MPCL CIM system. The MPCL data model is also being used for all TRW Marshall plant quality and performance data. The data model includes a mission critical failure analysis system that provides the foundation for the local RMA (Returned Materials) system. Remote control of the Marshall Factory Control and Work Cell Control functions from San Diego has been demonstrated.

In addition to these accomplishments within TRW, the CIM system has been adapted to Air Force depot requirements through the Warner Robins Air Logistics Center (WR-ALC) Lean Sustainment project. Another example of technology transfer is the Northrop Grumman use of MPCL CIM system implementation strategy and lessons learned in their PDM implementation project.

1 MPCL CIM System

The efforts of the MI IPT resulted in a working CIM system. The requirements for that system are captured Manufacturing Line Scenarios and Operational Scenarios (Section 4 and 5). The specifications for the CIM system are captured in the CIM System Design Description, User-Based Data Flows and Design Notes (Sections 6,7 and 8).

1.1 Goals and Objectives

In developing the CIM system, The MI IPT had the following goals and objectives.

- Provide tools and information systems to support product design efforts. These include analysis tools, CAD tools and design data storage.
- Develop and deploy a flexible CIM System that not only supports the existing high volume needs, but also provides for low volume and high mix scenario on the same production line.
- Enable the seamless flow of data from design to manufacturing.
- Integrate with the automotive factory MRP system.
- Test integration techniques with MPCL final assembly operations and expand the MPCL system into other automotive business processes.
- Automate the Quality Model.

1.2 Approach

The MI IPT adopted an approach that was cost effective and easily transferrable to other programs. In addition, the approach emphasized non-interference with ongoing operations at the Marshall plant. A summary of the approach follows.

- Develop a top down, modular system architecture that can be adapted to future growth.
- Avoid tying the CIM System to any particular vendor's tool or application, thereby maximizing transferability of technology to support the overall goal of MPCL.
- Insure the CIM System integrates seamlessly with the existing systems at the Marshall plant.
- Use off-the-shelf packages where possible to minimize custom design and increase robustness.

- Choose tools and products that have low cost licensing structures to avoid high recurring costs.
- Provide a simple and consistent method to interface and integrate to a variety of shop floor production equipment.
- Use the existing Marshall CIM development and maintenance environment so that the new system could be maintained without much additional cost to the Marshall Plant.
- Provide a secure network access for TRW and non-TRW personnel distributed over many parts of the country.

1.3 MI Accomplishments

Developing the MPCL CIM system involved a number of specific tasks. These tasks, listed below, are described in detail in the subsections of 2.3.

- Development of a distributed environment for the design of the MPCL products
- Using data modeling as the backbone of CIM System
- Development of a Factory Control System
- Development of a Work Cell Controller
- Development of a system that seamlessly integrates design and manufacturing
- CIM System Integration, Test and Deployment.
- Development of Factory Reports
- Demonstrating the CIM system through Marshall commercial product builds on the Flex 3 line
- Full use of the CIM system on MPCL products
- Development of a simple integration approach to the Marshall MRP system.
- Implementation of the Quality Model System as part of the MPCL factory system.
- Integration of the Router, ICT, Pack and Bar Code print stations for end of line production.
- Demonstrating remote production features

1.3.1 Distributed Development Environment

Task Description

The development team consisted of members from TRW/ASD located in Ohio, California and Florida; TRW AEN located in Marshall, IL; and software vendors located in Ohio and Canada. The requirement involved developing an environment in which this dispersed group could effectively work in unison to develop the MPCL CIM System.

Methodology

The requirements for Distributed Development Environment follow.

- Provide configuration management and data transfer capabilities to allow a simple and smooth transition from development, to integration/test and finally to production.
- Ensure security so that the various vendors could not see each other's source code and so that no vendor or contractor could access TRW's TI-Net or Marshall's plant Network Production Backbone
- Provide a secure network access (in terms of access to database, services, etc.) for TRW and non-TRW personnel to develop and test the CIM System.

The approach was to set up an NT Server on the Marshall Plant's network backbone with a Point to Point Protocol (PPP) dialup access for TCP/IP and NetBEUI. No IPX/NetWare protocol was supported over this PPP link. To make dialup more secure, a callback feature was set up whereby the Marshall Plant's administrator set the phone number to call back and guarantee that access was provided to "authorized" and password protected users only. This access was therefore restricted to known phone numbers established by TRW. To further minimize production and development separation, the TCP/IP development network segment was kept isolated through a smart switch that would not allow traffic to flow unless necessary. Since at any given time more than one person could be dialing, two high-speed modems were setup.

Results

Initially, there was some trouble getting some of the remote users correctly configured as most MIS personnel and users were unfamiliar with remote-dial-up network access procedures. In addition, some were using Windows 95 and others Windows NT. This further complicated setting them up at their sites. However, once the users were set up, the access and performance were deemed satisfactory. There was no noticeable disruption of development during the entire development phase. Overall, the capabilities and productivity that resulted with this distributed setup was comparable to those of a development group working in one location.

1.3.2 Data Modeling as the Foundation of System Design

Task Description

A Data Model was used as the foundation of the CIM system. The data model provides a plan for all information required by the system and accounts for the basic information required to run the plant.

Methodology

The approach adopted was to design a complete CIM System Data Model. Alternatives considered included using Process and Data Flows to first define the design functionality. This data model allowed integration of existing data structures with those of applications that were being developed. The data model addressed many types of information needed to run the plant floor. A brief description of each informational type follows:

- **Unit Tracking**
Production units are tracked by serial number throughout the data model. This area of the data model includes information on each serial number (when created, what product, ok to build, etc.) and information on the serial numbers history through the manufacturing process.
- **Manufacturing Site Configuration**
This section of the model tracks the operations and processes used in the manufacture of product. Each operation is located at a particular manufacturing location and provides a specific process needed to complete a product.
- **Product Configuration**
Each product uses a specific Bill of Materials (BOM), a manufacturing route, manufacturing instructions and machine setup. This is tracked in the model and can be frozen to insure a product is produced with the desired setup.
- **Machine Setup and History**
The system must track all raw material as used to provide containment and historical information. This section of the model tracks the supplier lot numbers used to build a given unit.
- **Part and Part Family**
Any part used by the system is tracked here. This includes top level assemblies and individual components. Part families allow parts to be associated with a given customer, line or suffix, and track package types for use elsewhere in the system.
- **Users and Groups**
System users have rights to applications based on group membership. These tables provide this information and also allow records to be tagged with information related to who performed the last edit or update on many applications in this system.
- **Quality Model Tables**

These tables support both the projection of quality levels for a given product and summary information on actual quality performance of any supplier, process or package type as related to production operations.

- Test or Verification Tracking Tables

Electronic assembly manufacturing requires several testing steps to insure electronic functionality. These tables allow the storage of test plans and test data for a variety of situations. This supports changing test plans through a product's lifetime while still allowing trending, tracking and SPC activities.

- Failure Analysis Tables

Once defects are identified, repair technicians analyze and repair units as part of the production process. This activity includes features to track analyses performed, repair location and action and associated cost data.

- Defect Codes and Menus

Defect codes are used to track product defects that occur in the manufacturing process. These tables allow a separate defect menu based on many factors including package type, process and location on line.

Results

Initially, the data model effort was started using experienced vendors. This allowed a draft data model to be quickly developed and subsequently used for design discussions and improvements. The initial data model was heavily dependent on use of off-the-shelf applications. As the design process evolved, the data model was refined to balance this with the needs of the MPCL program and the Marshall Plant's needs. As a result, considerably more time was spent on this activity. However, in the end, this approach minimized CIM system design revisions during the development and testing phases of the project. This model became the foundation for all systems planned for the Marshall plant floor. The model is shown in Figure 1.3.2-1.

1.3.3 Factory Control System (FCS) Development

Task Description

Once the design phase started, off-the-shelf packages were evaluated to determine their potential use in the FCS. The objective was to use available off-the-shelf technology to the greatest extent possible without sacrificing functionality in meeting the MPCL requirements.

Methodology

The needs identified for the FCS Development effort included:

- Provide opportunity to integrate off the shelf packages where possible to minimize custom development.
- Support interfacing to existing MRP systems, and allow for the MRP System to be changed in the future.
- Provide a low cost licensing structure for future systems within TRW.

The selected approach was hybrid in nature, combining one off-the-shelf package and with a vendor-specific factory control and configuration system. The vendor worked with the existing TRW design team and developed a custom factory control system. The factory control system was designed to meet the following needs:

- User Manager

The factory control system user manager is required to add new users and to select system rights based on group membership. This includes the ability to track skills to insure an operation is only operated by a trained individual.

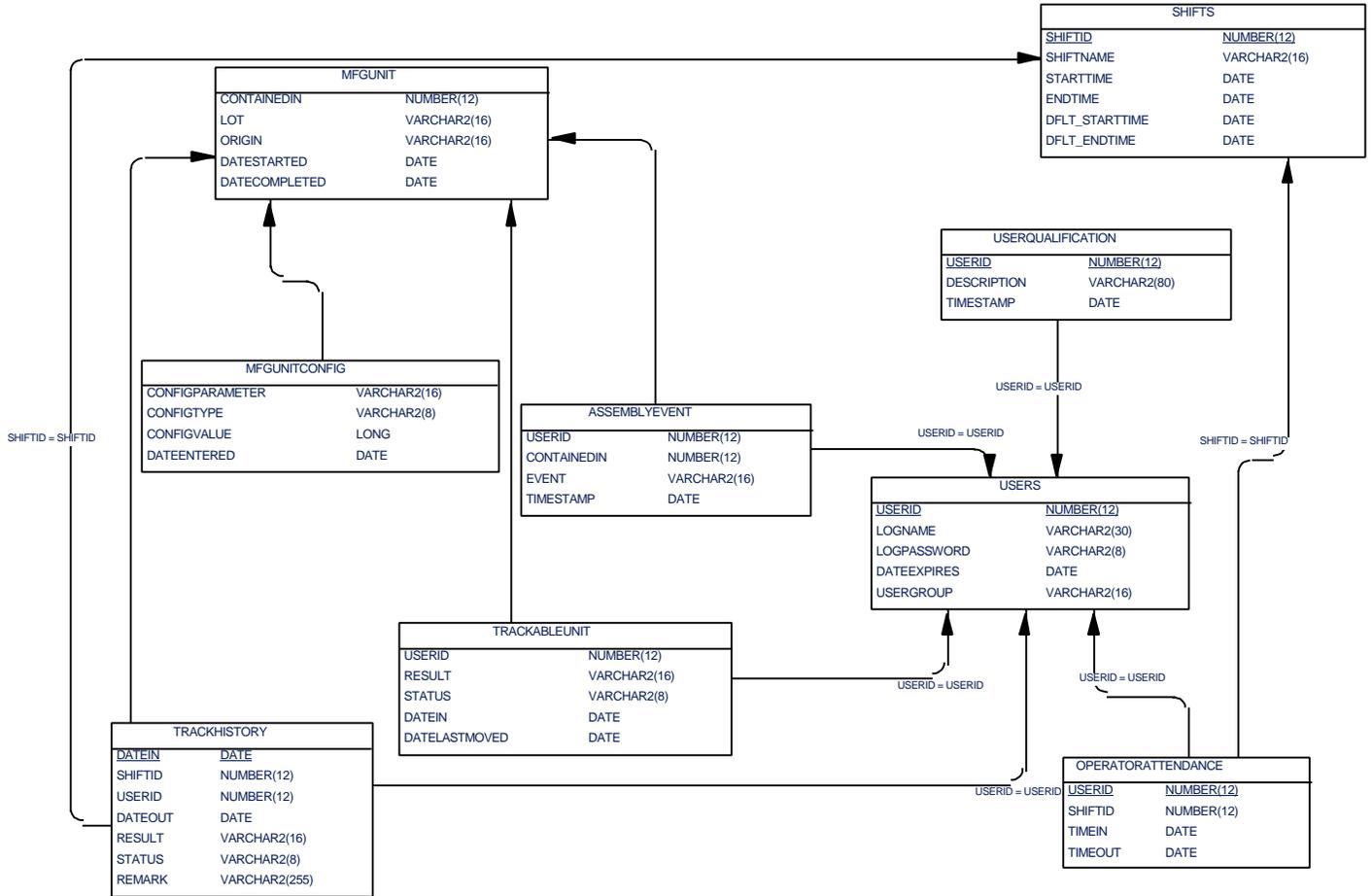


Figure 1.3.2-1. The MPCL Data Model

- Defect Manager

The defect manager allows the configuration of defect codes. This configuration allows a custom defect menu based on the actual production situation. Such an approach was selected to minimize the amount of codes that an operator has to select, reducing data entry time and reducing the occurrence of wrong code entry.

- Site Manager

This tool allows engineering setup of the factory operations, processes and manufacturing locations. An operation can not appear on the production route until it is added using this tool.

- **Route Manager**
The route manager sets the production route for a given product. This route can limit the number of repetitions of a process and the time allowed between processes. For example, a board must be re-flowed within four hours of solder paste application.
- **Setup Manager**
This tool allows a user to edit the part-to-slot relationship on every production machine. This relationship is initially set by the design-to-production system and only occasionally requires edit or change.
- **Part Manager**
The part manager allows the addition, edit or deletion of a part or assembly. Part families are also edited with this tool.
- **Configuration Manager**
A configuration defines the product, BOM, route, setup and instructions used for a particular production lot. This tool allows the user to select the correct setup for a given product and it allows the product to be frozen or locked into place.
- **BOM Manager**
This tool allows the creation, edit or deletion of a Bill of Materials (BOM). Since new BOM's are created by the design-to-production system, this tool is typically used for editing purposes only.
- **Instruction Manager**
Each operation has process instructions or programs to perform the given operation successfully. This tool allows the user to determine what instructions or machine programs are required to produce the product. This also allows check boxes to be displayed and checked off as part of the setup or change over process.
- **Schedule Manager**
The schedule manager determines what can be built by the line. It uses a continuous flow model that can accept varying lot sizes to support either high volume or low volume product mixes.

Results

Like any custom development effort, there were some hurdles to overcome such as making trade-offs between flexibility and robustness or between new tools offering added performance and proven tools. These tradeoffs took a bit longer than expected and hence there were some delays in getting all the development done within the original schedule. However, this minor delay in developing the FCS had no impact on the overall schedule for MPCL.

1.3.4 Work Cell Controller (WCC) Development

Task Description

The objective was to migrate as much of the Marshall CIM technology and investment into the MPCL CIM System without sacrificing functionality in meeting the MPCL requirements. Similar to the FCS development, off-the-shelf packages that would address the WCC requirements were evaluated.

Methodology

The needs identified for the WCC Development effort included:

- Support the Marshall Plant's goal to migrate as much of the developed CIM technology and investment into the MPCL CIM System.
- Provide a simple and consistent method to interface with a variety of shop floor production equipment to support Program Upload/Download.
- Synchronize with the existing CIM development and maintenance environment so that this new WCC system could be maintained without additional cost to the Plant.
- Provide a low cost licensing structure for future systems within TRW.
- Allow a sophisticated and simple method to input defect data at any station. This method employs the CAD files to draw a picture of the product allowing a touch screen entry of the exact defect on the exact part. The system tags this information to the correct serial number and allows a "repair it later" functionality.
- Control the production line to insure the line would not produce product unless all start-up conditions were satisfied (correct material in correct slots, valid route, valid BOM, valid timing, etc.).
- Allow the display of process instructions and checklists at each operation to support a paperless system.
- Support data input from users in three different ways to accommodate different levels of computer skill and manual dexterity. The three methods included keyboard, mouse and touch screen.
- Provide an advance notification of changeover to downstream stations to speed changeover.

The approach was to use the same base tools and Graphical User Interface (GUI) technology used at Marshall on other lines to develop the WCC. This included using Visual Basic 4.0 as the development language of choice and using the existing Real Time Feedback System's GUI as the basis for operator interaction. In addition, to support different databases and allow the WCC development to integrate with existing databases at Marshall, a compatibility layer using Open DataBase Connectivity (ODBC) methodology was used. This allows the WCC to be deployed on other databases with minimum changes to the WCC source code.

Results

Overall the development effort for the WCC required a joint effort among TRW AEN, TRW ASD, and two separate vendors. Even with this distributed development, the effort progressed without setbacks. As issues came up, they were resolved. Each group was able to get “stub” (black box) code developed that interfaced with each other. The resulting code has been implemented on at least 13 computers covering about 20 operations used for the MPCL product builds. Product work flows in both Marshall and San Diego are controlled by the WCC. QS-9000 requirements are also supported as required to maintain certification.

1.3.5 Design-to-Manufacturing System

Task Description

The objective was to take the various design outputs and provide a set of interface utilities and tools that would simply and efficiently extract the manufacturing data from the design database and populate the CIM database. Many of the Factory Control System (FCS) applications are used to support this system. This system assumes a minimum of CIM support by providing engineering applications for system setup purposes, negating the need for setup by Marshall CIM engineers.

Methodology

The needs identified for the WCC Development effort included:

- Provide a standard method to define interfaces to a variety of CAD System outputs.
- Provide tools and utilities for a number of data elements, including Component Placement Data, Solder Mask Bitmaps, Engineering Bill of Materials and Selection of Reference Designators.

A detailed methodology and flow chart was created to show how the “approved” design data and supporting files would be transferred from the design center to the manufacturing center. The methodology included what processes performed by whom would result in the extraction of the manufacturing data. To assure compatibility with Marshall, Visual Basic 4.0 was the development language of choice. The existing Marshall design-to-manufacturing utilities for the Caterpillar diesel engine control products were the basis for this development. Different CAD outputs were put into a “universal” common format to be used to extract the data to the CIM database. Several vendor packages were evaluated to determine if they could be applied or used. The conclusion was that vendor tools would not provide all the utilities and would require more work to customize and integrate than evolving the existing Marshall tools to meet MPCL CIM needs.

Results

The use of the design-to-manufacturing system is expected to decrease the time required for design to manufacturing from a typical 200 hours to less than 20.

1.3.6 Factory Reports

Task Description

The MPCL CIM system provides support for a variety of reporting needs of the factory. Factory reports support engineers, who configure and monitor the CIM System, supervisors who manage the production line and operators who operate the equipment.

Methodology

The needs identified for the Factory Reports development effort included:

- Provide the capability to easily create and distribute new reports in textual and graphical formats with “drill down” capability.
- Integrate off-the-shelf reporting packages where possible to minimize custom development.

- Support not only the real time needs of the line for immediate status, but also the need for configuration, supervisory and management reports that cover more than one shift's worth of data.

The methodology used was varied. For the WCC, where the reports required are "immediate" and well defined, a graphical reporting engine was integrated within the WCC. The reports here included basic production and defect data in graphical format with Pareto charts to identify cause. On the FCS, where the needs for reporting will constantly evolve and change, an Oracle report-generation tool was selected. Using this tool, new reports can be developed and quickly deployed. A number of reports have been developed that can simply be accessed from the FCS Menu. This tool also provides the capability to have reports shown on the screen or printed to any system printer.

Results

Defining and developing reports is generally difficult since there is a continuous need for new reports or enhancement of existing reports. WCC reports that were well defined and would rarely change were tightly integrated with WCC. However, in the case of the FCS area, flexibility is needed, and it is more important to have a tool that allows quick creation and deployment of new reports.

1.3.7 System Integration and Deployment

Task Description

The objective was to integrate all the different applications that make up the MPCL CIM.

Methodology

The needs identified for the system integration and deployment effort included:

- Perform as much of the system integration effort as possible prior to the Design Validation (DV) and Process Validation (PV) builds.
- Use MPCL boards during DV and PV to perform system integration.
- Deploy on Production Flex Line 3 to support board production for MPCL only.
- Start with a "new" database and "newly" deployed WCC stations to identify any issues with a full-up production roll-in.

The Preliminary System Integration and Test effort was started in the development environment. This environment provided basic testing and system integration of the CIM System. Initial bugs and issues were resolved prior to any DV or PV builds. At the time of the DV build, system integration testing was performed to determine how the newly integrated system improved monitoring and management of the production process.

Results

The results in this area were mixed. One of the two major problems was that the time allotted to set up and test the WCC stations was very limited. The second problem was that not enough time or boards were allotted for the MI Team to truly integrate the system. As a result, a lot of work still remains to be done to "proof" the entire system from start to finish.

1.3.8 Demonstrating the CIM System through Commercial Product Builds

Task Description

A commercial product was manufactured using the MPCL CIM system. The chosen commercial product was normally produced on line 3, but without the benefit of a CIM system. This task was chosen to help meet the goals of proving final deployment and the expansion of the MPCL system into the automotive business. The build of the commercial product would use the full system,

including automated system setup (design to production system), release into production with the “FCS” applications and production line control with the “WCC” application.

Methodology

The commercial product used the same CAD system as MPCL products (Mentor). This allowed a direct test of the entire system, from design through build. The builds required the CIM system to incorporate existing plant processes derived from QS-9000 standards. They also required a level of training and involvement by the document control department to insure configuration standards were met and that change control was enforced.

Results

The commercial design center provided the product design files in a standard text format (neutral files). Some minor component updates had been made to the product since the last computer design effort. These changes were noted and were input once the automated phase of product setup was complete. The utilities in the CIM factory control system were able to read the design files without major issues. Minor issues included the lack of “line feed” characters in the neutral file requiring a simple adjustment in a word processor. The outline of a few components as rendered in the on-screen graphics required small corrections. The system BOM, on-screen graphics and associated files were correctly translated from the neutral file into the Oracle database.

Machine setup information that define the part numbers to be loaded into each machine slot were loaded from files provided by the machine programming engineers. These were automatically loaded without issue.

Once the neutral file was loaded, the route defining the operations that were required to build the product were entered into the system. Document control associates then loaded process instructions into the system and assisted with a 100% check of the BOM, setup and instructions prior to release. Issues noted included some errors introduced by manual entries of changes that were not reflected in the design files.

Scanner locations had to be modified on the MPCL boards to support the bar code location required on the selected commercial product.

The build was then scheduled in the system and material was loaded on the machines. Minor issues were encountered while scanning in the raw material due to slot number errors in the data. The system did not allow the line to run until these issues were resolved, preventing the build of non-conforming product.

The product flowed down the line smoothly. The system insured the correct route was utilized and no further issues were encountered on the first several operations. A hardware issue was encountered between operations 123 and 125. These two assembly machines were combined into one operation in the MPCL CIM system on earlier builds. The flow of the product between these two operations allowed some boards to pass prior to a check of the database to insure configurations and routes were correct on that particular serial number. The CIM system used a clever interface to control the conveyors without requiring modification of the PLC control code. It was determined that this approach only worked when there was a conveyor between two assembly operations.

Operations 123 and 125 were connected directly and therefore will require a different flow control method (such as hard pneumatic stops).

Overall the build results were excellent and the CIM system performed as intended.

1.3.9 Full Use of the CIM System on MPCL Products.

Task Description

Use of the MPCL CIM system for MPCL production is an obvious project task. Several PV (production validation) were manufactured during Phase III. This included both PV and production builds of PNP and FEC modules (A and B-sides).

Methodology

Full system setup and deployment was implemented for each build. The two MPCL products (FEC and PNP) were divided into 6 assemblies within the CIM and MRP systems. This configuration supported the assembly process. For example, one PNP unit is produced as a PNP side A, PNP side B and PNP assembly (combination of side A and side B).

Earlier builds completed during Phase II focused on the central functions of the system. These included the basic Work Cell Controller (WCC) functions, board and material scanning, conveyor control and defect entry. These central functions worked without fail during Phase III production. Phase III demonstrations focused on insuring the system would perform during actual builds. System reports were fully tested with actual data allowing a more complete systems check.

Results

Minor issues with late changes were detected by the system during setup and were quickly resolved. These changes consisted of minor slot changes for material and a couple of late component changes. The line computer systems worked as designed during the build. A number of minor issues with the Factory Reports were corrected as they were identified. One issue was the need to clear the slot location data tables after a material lot change.

1.3.10 Development of a Simple Integration Approach to the Marshall MRP System.

Task Description

The task of integration with the MRP system was planned for Phase III. Marshall had a planned change of its MRP system due to Y2K issues and other considerations. This change was planned to be complete during Phase III activities, but was delayed. This forced the MPCL MI team to create an interface for MRP systems that was generic and easily adaptable to any future system that would be considered. This interface was a compromise since the preferred integration approach would have involved sharing existing tables within each system.

The import of data into the MPCL CIM system was identified as an area of concern. The team decided on a flat file transfer technique with the intent to improve this system once the new MRP system was deployed and stable. The task then became the development of generic tools for such transfers.

Methodology

The adopted approach allowed the input of data to the CIM data model from external, comma delimited files. Since the MRP system is known, the application would be generic and would include a few standard input formats. Future inputs could then be added with minimal effort requiring only a SQL query and configuration file changes to add new imports.

A generic data import tool was designed that could be used to transfer information into any part of the data model. This tool was designed using the modular functions that support the WCC and factory level applications.

Data output to the MRP system was added via the reporting functions. The current reporting functions provide output in both report format and text file format. The text file format is intended to support the required flat file integration.

Once the MRP system is in place and considered very stable, these interfaces should be eliminated. Direct access to tables would permit seamless integration assuming the MRP system is master for configuration data and the CIM system is master for the “as built”and WIP information.

Results

The data import application was developed with a standard input of the BOM. The BOM was selected due to it’s central nature and because it impacts a number of tables in the data model The interface for the data import tool is shown in Figure 1.3.10-1.

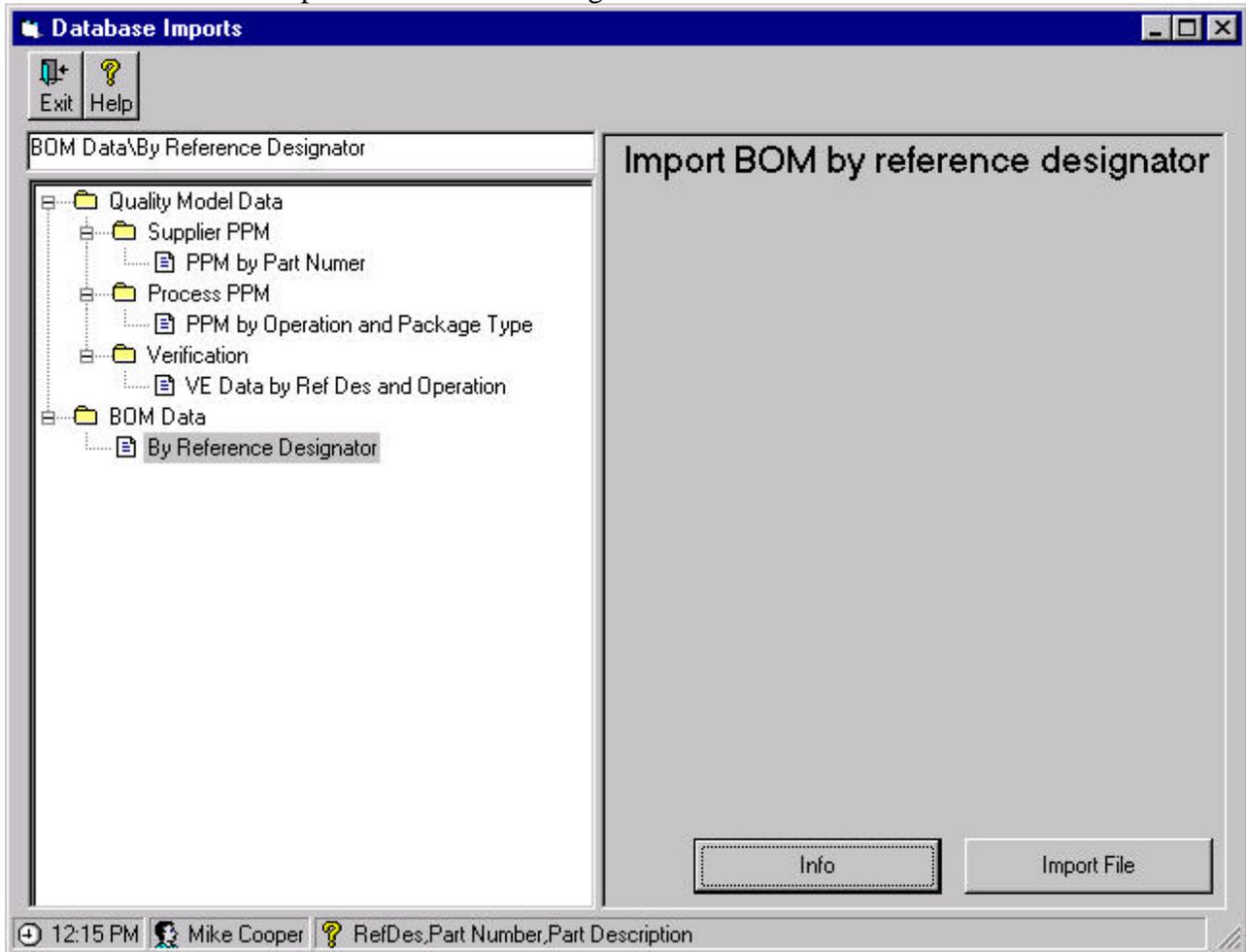


Figure 1.3.10-1. Data Import Tool Interface.

Selecting an item on the tree and then pressing the OK button displays another dialog box that lists the information needed to complete the import. This form is shown in Figure 1.3.10-2.

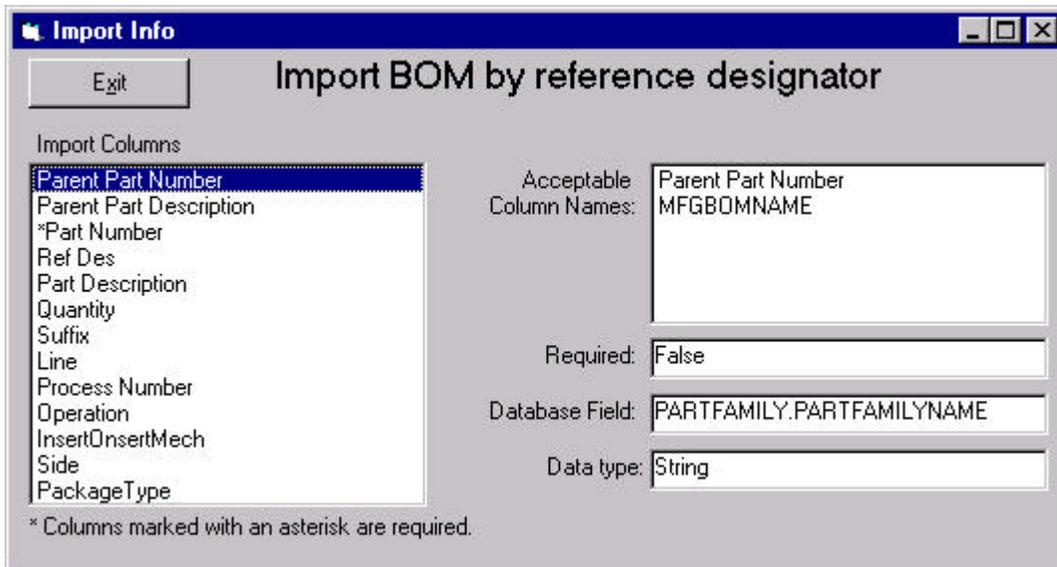


Figure 1.3.10-2. Data Import Tool Dialog Box

This format is intended to be setup by a CIM engineer, who would create a new import type and then any office user with sufficient rights could use it. Other potential areas for input from the MRP system include the Route, component assembly by operation and scheduling information.

1.3.11 Implementation of the Quality Model System as Part of the MPCL Factory System.

Task Description

The Quality Model (QM) is a set of methodologies and procedures that enables the quality of a product to be defined in terms of PPM (part per million) failures. This methodology consists of identifying the key contributors to product quality problems and verifying the elimination of these contributors. The Quality Model runs as a routine under the CIM system, using data collected by the CIM system.

Methodology

The approach was to exercise the model manually and then use the experience to automate the process. Five models were completed manually on FEC A, FEC B, PNP A, PNP B for MPCL and two commercial products. The manual effort refined the approach and provided feedback on techniques for automation. While much of this effort was semi-manual (excel spreadsheets) the base information was maintained in a manner that closely matched the planned data model. The experience from these manual efforts was then applied to the development of the automated system. The data model was refined and a complete specification was generated prior to coding. The specification defined all user interfaces and data base tables. The resulting automated system used data modeling techniques and user interfaces to minimize the amount of data input. The main function of the Quality Model is to allow new designs to be rated for their quality potential. To achieve this, a number of the following functional elements have to be made available (Figure 1.3.11-1).

- QM shall maintain parts-per-million (PPM) values for processes and supplier parts and history for PPM changes.
- QM shall maintain process verification effectiveness and history for effectiveness changes.
- QM shall compute and display the results of the product PPM based on PPM inputs of supplier parts, processes, and verification effectiveness.

- QM shall provide a set of reports to provide the results of the quality model PPM for the product.

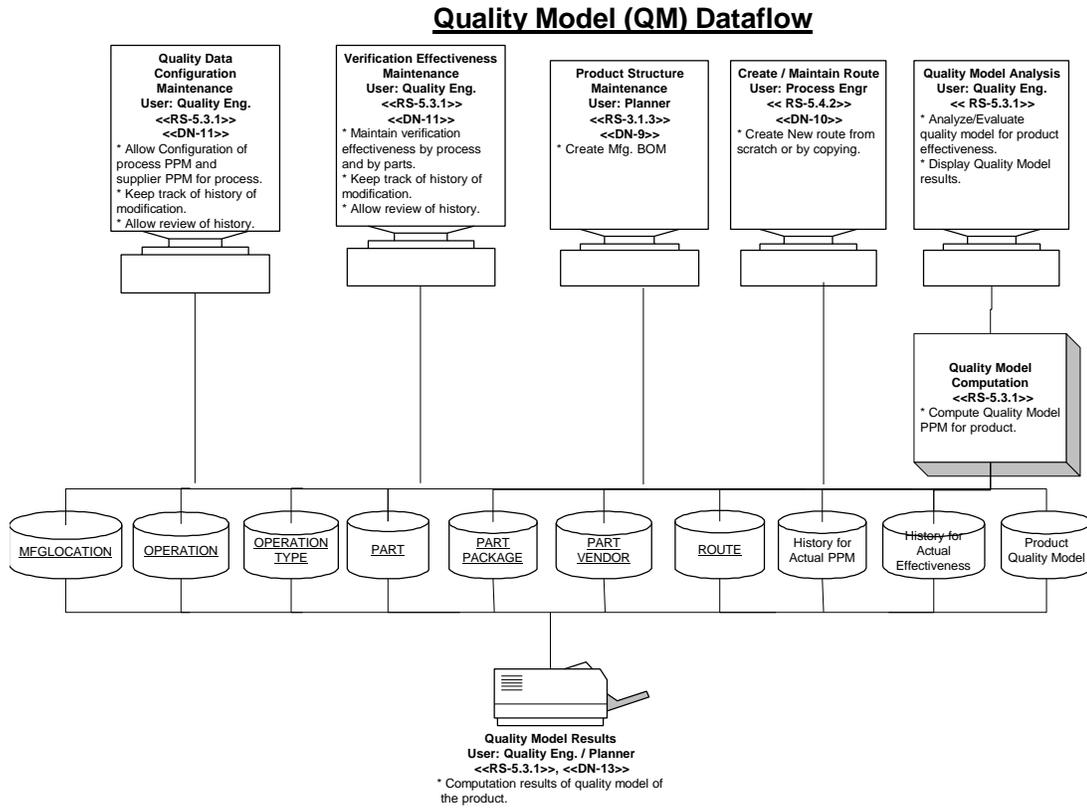


Figure 1.3.11-1. Quality Model Dataflow

Results

In general, a user will start the application as discussed above and get into the QM or FCS Screens. This will be modeled similar to the FCS screens. The time will be synchronized with the database time using the Compatibility Layer functions. Once the QM Opening Screen comes up, the user will be guided to all other screens necessary to create, modify or view either a Quality Model or a Default Prediction Set. The first screen is shown below.

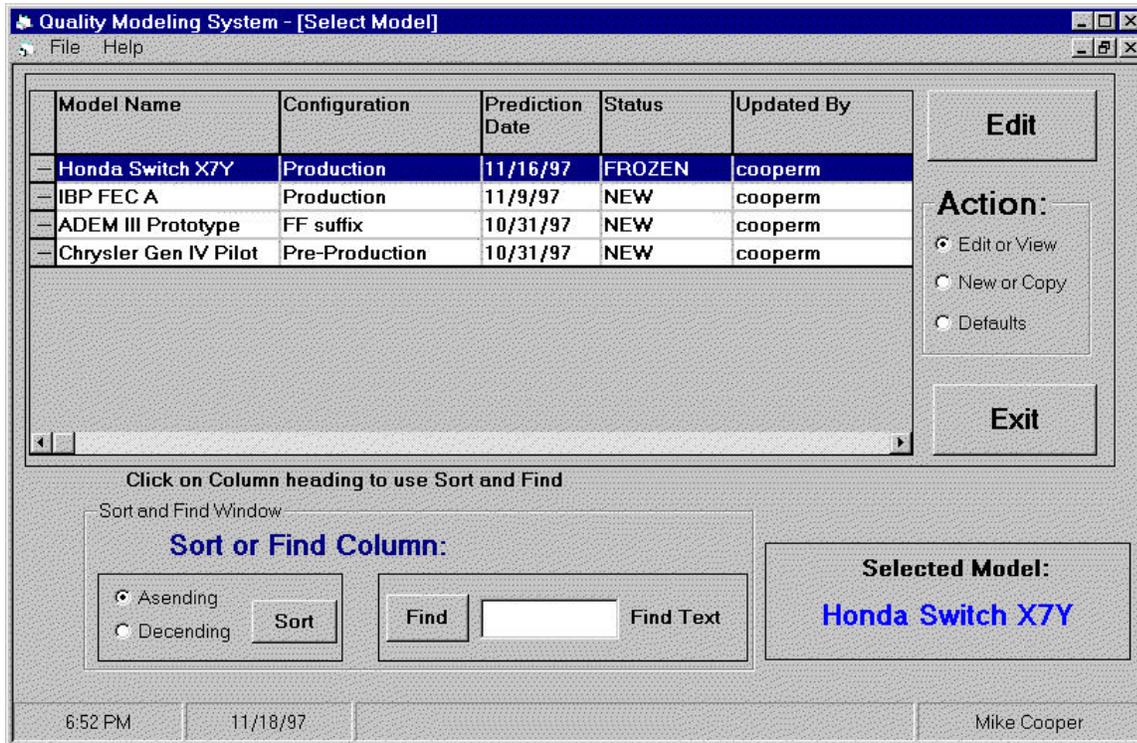


Figure 1.3.11-2. Quality Model Top Level Screen

This screen allows the user to manage all quality models in the system. Provisions for editing a selected model are included. One must view a model in order to view reports since the reporting functions are all model-specific in nature. New models are also created from this screen. A new model can be either completely new or a copy of an existing model. This allows the easy analysis of several "what if" scenarios or design approaches. Data entered into the system is automatically used as default data on other products that use the same line and operation. This default data can be viewed and edited independent of an individual model if needed.

Once a model is selected for editing, a screen shows the model status and predictions as they are entered. The main Quality Model edit and view screen is shown in Figure 1.3.11-3.

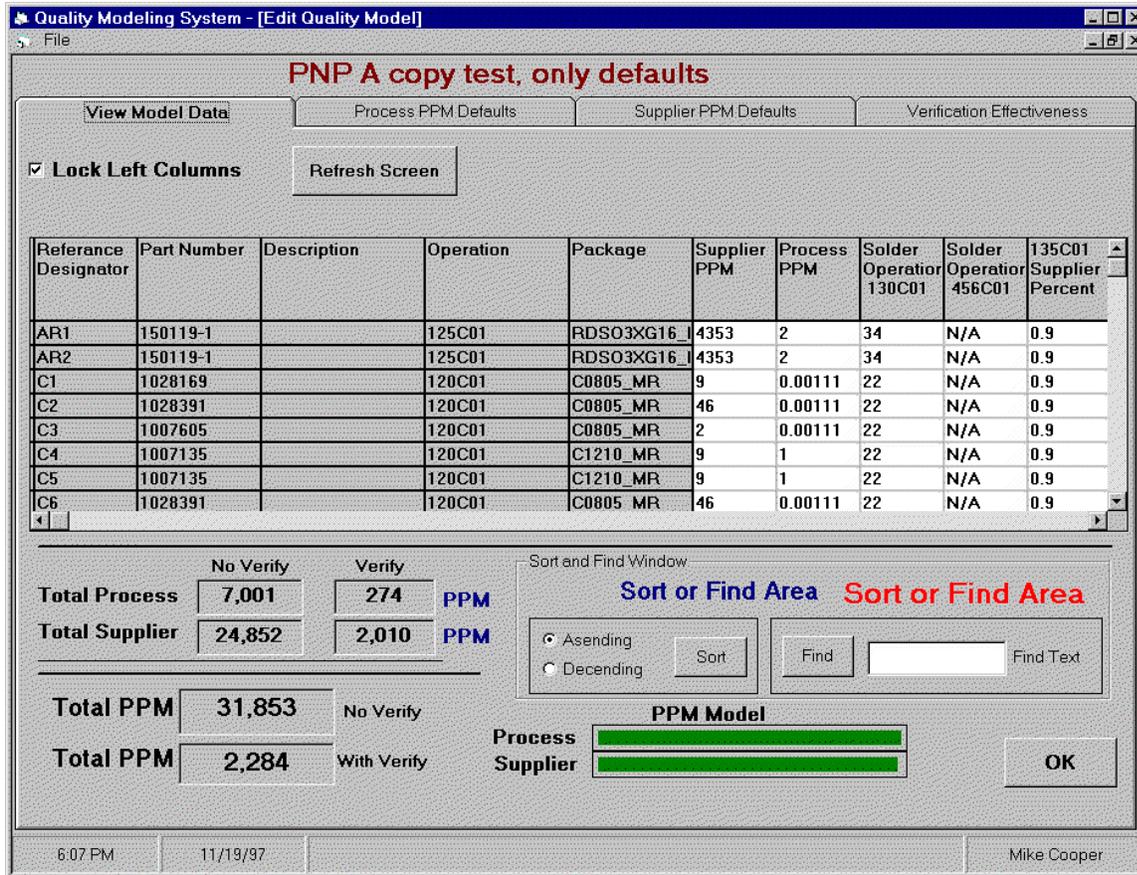


Figure 1.3.11-3. QM Edit and View Screen

The model details are shown here by reference designator. Green bars show how much of the required supplier and process data is entered. The total PPM rates at any point in the modeling exercise are calculated and displayed on this screen both with and without verification applied. Other tabs are selectable to edit process, supplier and verification data. The supplier and process PPM screens are similar to the above screen. The verification screens are slightly different as shown in the Figure 1.3.11-4.

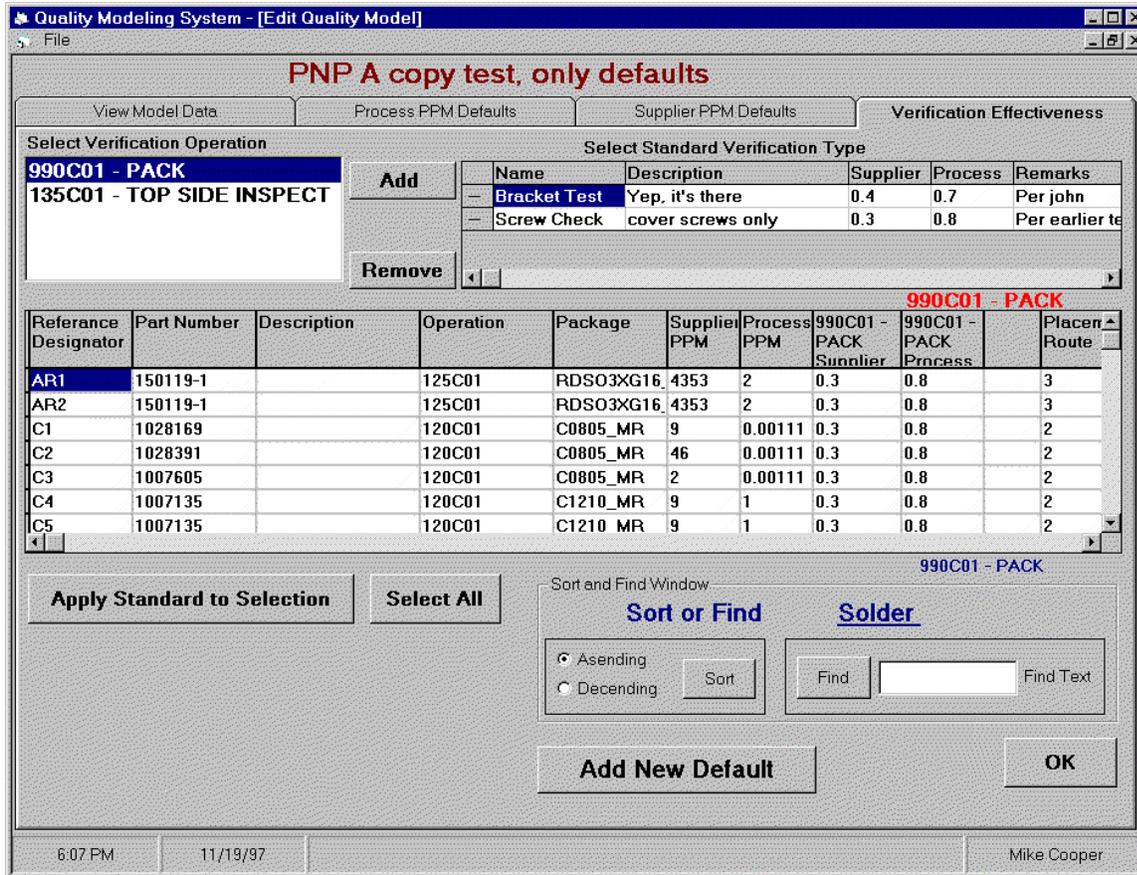


Figure 1.3.11-4. QM Verification Screen

Verification information can be entered on any process on the production route. A set of standard verification types are maintained by the system requiring the user to simply tag the verification type to the operation and reference designator involved.

Once a model has been completed, graphical reports are available to assist in managing the quality of the product and processes being modeled. Excel spread sheets of the entire data set can also be generated by the system for off-line analysis. An example of the graphical output of the quality model is shown in Figure 1.3.11-5.

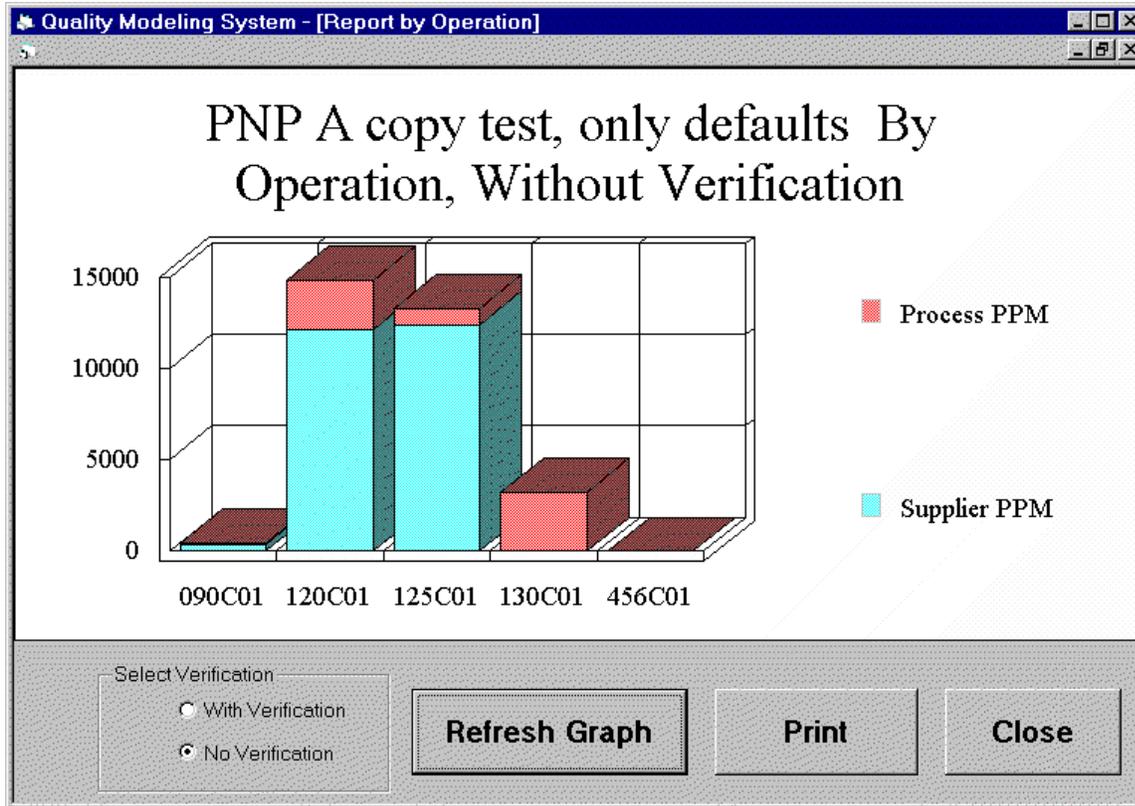


Figure 1.3.11-5. QM Graphical Output

An implementation that maximizes the value of this tool should involve a gradual rollout and accuracy check. The accuracy of the tool is directly related to the accuracy of the input factors involved. All models must grow and improve over time to remain useful. This evolution involves comparing model data with actual results and the adjustment of input factors based on actual data.

Starting with modeling all products on one line and then proceeding to the next line is recommended. This implementation maximizes the benefit of the automated system since the first product on any given line is the most work. Once the first product is modeled, other products can be modeled quickly on the same line since they use many of the same processes and thus use the same default data.

The tool allows data input for a given product and line or data input for global values. The recommended focus would be on a product by product basis rather than on entering defaults. Verification effectiveness data can only be entered on a product by product basis.

The most pressing issue in terms of deploying this system is the input of BOM data. The MPCL system is designed to accept BOM data directly from the CAD files. Different file formats could cause a data transfer problem. The data import tool designed for MRP integration helps resolve this issue.

1.3.12 Integration of the Router, ICT, Pack and Bar Code Print Stations for End-of-Line (EOL) Activities

Task Description

The end-of-line stations utilize the WCC software in much the same way as the front-of-line systems. Proving the WCC application on these stations was planned for phase III to allow fixturing to be completed for these processes and to allow time to test various integration approaches. The EOL stations provide the opportunity to:

- Test the WCC functions in greater detail.
- Test the ability to run the WCC and a current CIM application simultaneously.
- Test the ability to integrate standard WCC function calls to existing software.

The operational scenario for each station is almost identical to those outlined in Phase II with the exception of manual board scanning. The manual board scanning at the router and ICT involve scanning the individual serial numbers rather than panel numbers. Once the two sides are bonded together, they will continue to be tracked separately through the system until the external bar code can be printed. A short description of the Phase III task for each EOL station follows:

- Depanalization Router

The router removes the individual circuit boards from the multi-up panel. The modification to the WCC on this station was planned to insure the correct fixture is used. The WCC insures that the correct material and programs are in place on other machines but the fixture issue makes the router unique.

- Bed of nails in-circuit test

The in-circuit tester does a node-by-node test of the assembled board. It is the only major verification operation employed by the assembly plant. The WCC software must enforce the pass/fail status from the ICT insuring that boards that fail ICT are not allowed to proceed in the process.

- End-of-Line Assembly

There are a number of WCC stations involved in the final assembly of this product. These operations generically apply adhesives or coatings, oven cure, hot bar soldering, repair and final mechanical assembly. The unique attributes of these stations include the implementation of multiple operations at each WCC and the planned change over between every unit. The WCC was designed to allow multiple operations but the end-of-line stations provided the best opportunity to complete the testing and deployment of this capability. A unique method of using the setup and change over features was implemented for phase III. When sub-assemblies are physically joined (core bond) they are also logically joined in the database system. On the MPCL products, however, there were production engineering reasons for providing physical attachment at the start of the final assembly area but delay the logical joining until the end of final assembly.

- Label Printer

The label printer is the point where the two subassemblies are logically joined and assigned a unique serial number. This is despite the fact that the sub-assemblies were physically joined many steps earlier in the process.

The team made the decision to test the ability of standard functions to be employed in existing commercial software on this work cell. At all other operations, existing software has always been added to our WCC application resulting in a single, very flexible and powerful application. This is considered desirable in almost all cases. There are instances, however, where it will be much more effective to update existing software by adding the MPCL functions to the older code in lieu of adding it to the WCC. Therefore, in one case the team took the current label printer software and replaced the existing database functions with the standard MPCL functions.

- Pack Station

The pack station is the final operation prior to shipment to San Diego for final testing. A third integration technique was tested on this station. Since a mature pack system existed in the current commercial operation, a dual application approach was chosen that would require both the WCC and the current pack software to run concurrently for the one operation. The planned task would be to minimize changes to either the pack or the WCC code and to configure the WCC code in such a way as to allow both systems to run simultaneously. Since the old software accesses its routing verification database via RS-232, a cable would literally be run from one port connected to the pack software to another port on the same machine, operated by the WCC application.

Methodology

The combined goals of integrating the end-of-line and the goal of testing integration approaches were tested independently due to the number of operations used in the end-of-line. In each case integration would be accomplished with minimal change to the application software and no changes to the data model. This is realistic given the mature state of the data model and the configuration of the WCC application.

Where custom integration is required, the standard functions and approaches were used.

Results

The goals of integrating these final operations and the testing of integration approaches were both completed successfully. If an integration approach failed, we would simply apply another method to achieve the needed functionality. This back up plan was however not needed since each level of integration was deployed successfully. Notes on each approach are outlined under the specific application as follows:

- Depanalization Router

The router uses the WCC application in the normal fashion. This operation is the first production test of the system's ability to track a panel of units, then track the individual units after depanalization. The router WCC is uniquely responsible for marking the panel numbers as complete and enabling the individual units to move to the next operation in the process. It also confirms the correct fixture and program are in place prior to starting the operation. Despite some problems with customizing the router, the team was able to implement a workable solution.

- Bed of Nails In-circuit Tester

This tester would use the WCC application in the normal fashion. This operation is the only production operation that fully uses the pass/fail aspects of the CIM routing functions. This insures that a board that fails will not proceed through the process.

- Label Printer

Integrating the label printer station involved using existing software and adding a minimum of MPCL functions. The team automotive business currently uses label-printing software on many production stations providing relatively mature software and interfaces. The label printer stations support the following MPCL functions:

- Select the correct schedule from the MPCL data model.
- Check prior step status of a scanned unit (should it be at the label printer).
- Create the top-level serial number in the MPCL system.
- Complete the two (side A and B) serial numbers in the system to prevent further processing of the individual boards. (Dropped to allow defect entry at remote plant)

- Add information to the system to tie the completed units to the top-level number. The completed units are then sub-assemblies of the final serialized unit.
- Print two labels for each unit (one for the module, one for the shipping bag)
- Save tracking data on the new serial numbers to the database (date and time through the process)

Minor interface modifications were needed since the production software assumes there is only one serial number subassembly. The modification will allow the scanning of two units prior to printing the label. The software would also confirm that the two subassembly serial numbers can be joined (cannot attach FEC A to PNP B for example).

The existing code was modular and well written making the integration task straightforward. The existing program first was converted to 32 bit to be compatible with the MPCL database functions. Then each function was added and tested without major issue.

- Pack Station

The commercial business has a mature pack station application that was selected for this integration test. The integration plan for pack is to use the current commercial software without modification by running the normal MPCL WCC program in the background. Thus the user would only see the pack software with its familiar interface. To accomplish the goal of using the pack software without modification, the following steps were required:

- Modify the WCC application to look like an RS-232 prior step port to the pack software.
- Set up the current software to run MPCL product, including the commercial databases.
- Wire the RS-232 ports to allow the pack software to interface with the MPCL system.
- Test the integrated system.

Step 1 involves a minor change to the WCC application. Part of the original WCC specification was the ability to integrate with the current RS-232 prior-step system as a client. This step requires the WCC to act like an old prior-step server when connected to the pack system. The operational scenario would proceed by first scanning the board into the pack software. The pack software would request the status of the module over the RS-232 connection as it does today. The RS-232 connection would be routed into the same machine and would be answered by the WCC software after checking with the Oracle database. The WCC software would handle all normal database functions and the operator can click on the WCC icon to view schedule, setup and process instruction data, or click on the pack software to perform the final pack operation.

Step 2 requires simply setting up the commercial configuration databases to run the MPCL product. Since we did not modify the pack software, it must be setup with information on the allowed serial numbers, prior step codes and pack carton quantities.

Step 3 is just a short piece of RS-232 cables going from Port 2 to Port 3 on the same machine. The pack software is programmed to use Port 2 while the WCC uses Port 3. This interface is all that is required for the two systems to communicate and function correctly.

1.3.13 Demonstrating Remote Production Features

Task Description

The MPCL system is designed to be accessible from anywhere on the planet that has either a phone line or an IP Internet connection. The only planned production use of this feature is the final testing processes in San Diego. The task therefore is to set up the full Factory Control System and the Work Cell Controller in San Diego. Once setup, the factory system was tested, including reports

and system configuration. The WCC application was configured to run the final four verification operations for production units.

Methodology

Installation in San Diego was performed in the same fashion as in Marshall. The San Diego - operations were configured as part of the production route that starts at the end-of-line label printer (the route starts there when the top-level serial number is created).

Results

Installation of the full system in San Diego proceeded without major issue. The database was accessed over the phone lines and provided acceptable response times. The factory and WCC applications were moved to a local machine, however, to improve performance.

Defect entry became an issue since San Diego has the need to either enter defects against the unit (missing screw for example) or against an individual board (bad U5). This need was not anticipated and an approach was developed that would 1) display the outside package if the outside serial number was scanned and 2) display the detailed PCB graphic if the inside label was scanned. This impacted the label print station slightly since the stations completed the inside unit during label print. It also impacted the WCC application since it would have to provide both interfaces.

1.4 Conclusions and Recommendations

Overall, the MI project has been completed successfully. Phase III provided sufficient time to complete training and deployment of all the system elements. The current system is ready for any production use or new design from the program design center in San Diego. The low volume of production from these sources will make system training and support an issue. Further deployment of the MPCL CIM system will eliminate this issue by more frequent use thereby building a larger group of trained system operators.

Actions required to expand the CIM system beyond the current implementation include developing interfaces to other design centers and deploying the production system to other commercial lines

Appendix 1 - Manufacturing Line Scenario

1. Manufacturing Line Scenario

Appendices 1 and 2 focus CIM Operational Scenarios - the Manufacturing Line Scenario and Operational Scenarios. The Manufacturing Line Scenario provides an overview of the manufacturing line along with the common elements and major issues addressing the CIM System. The Operational Scenario provides a detailed description of the operator interaction with the major components of the CIM System. In support of the MPCL CIM Project, Flex Line 3 will be used at the Marshall Plant

Flex Line 3 as discussed here is currently in transition. Based on data currently available, we are assuming what process machines this project will use. The MPCL-PT Team has selected the Flex Line 3 as the line to produce and MPCL PWA. The stations to be used are:

1. Bar Code Label Application Station
2. PWA Board Handling (Loader) Station
3. Screen Print (MPM UP 3010) Station
4. Adhesive Dispensing Station
5. Inspection Station
6. Off-line Reel Loader Station
7. Fine Pitch Chip Shooter (MV II) Station
8. Ball Grid Array Top Side Placement (Universal GSM) Station
9. Inspection Station
10. Reflow Oven (Electrovert ATMOS CR2000) Station
11. Inspection / Touch Up Station
12. Board Label Application Station
13. Wash (Westkleen) Station
14. PWA Depanel Station
15. In-Circuit Test (GENRAD) Station
16. Core Bond Station
17. Hot Bar Station
18. Flex Attach Station
19. Inspection / Touch-Up Station
20. Repair Station
21. Conformal Coat Station
22. Final Assembly Station
23. Pack and Ship Station

These stations are laid out in the form of a “line” concept (as shown in the figure below) so that a Printed Wire Assembly (PWA) starts on one end of the line and works its way to the other end.

The above sequence provides the general flow of the PWA starting at the Bar Code Label Application and ending at the Pack and Ship Station. The following sub-sections discuss the major operational items and issues.

Flex 3 IBP Line Layout

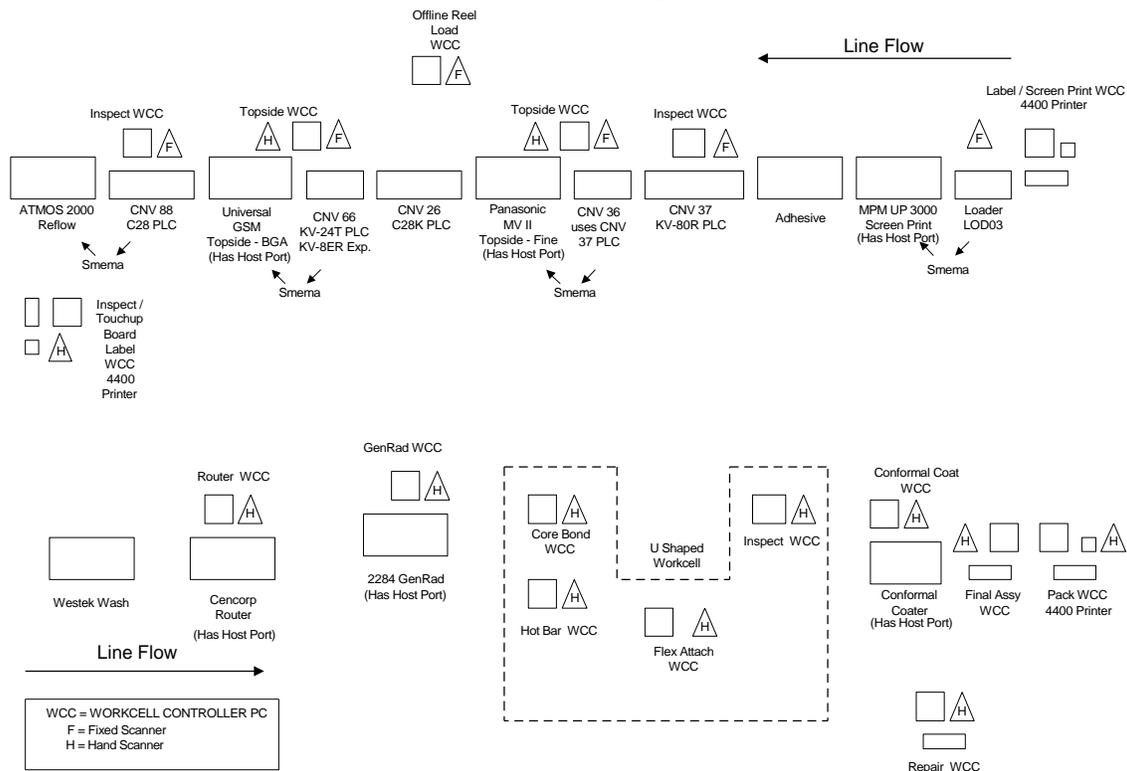


Figure 1-1. Flex 3 IBP Line Layout

1.1 Manufacturing Stations and Operations

Each of the physical locations where work is performed is considered a “station” or a manufacturing location. Wherever a PWA is inspected, tested, added to or changed, that functional entity is an “operation”. Typically a station performs one operation, however that is not strictly adhered to. For reasons of production there may be many “stations” that perform the same “operation”.

Conversely, for activities that are sporadic, or do not require significance amount of work, there may be many “operations” performed at a single “station”.

In this document a simple one to one approach is assumed. However, the design of the CIM System should not be restricted as such. It should allow many stations to perform the same operation and support many operations to be performed at the same station with minimal Factory Control System (FCS) configuration.

1.2 CIM MPCL Vs. CIM Today Mode of Operation

The focus of the operational scenario is to define how each of the stations will operate in "CIM MPCL" mode. Each of the stations shall be "operable" in a "Original CIM" mode.

The default CIM-MPCL mode of operation will have the following characteristics:

1. In the "CIM MPCL" mode of Operation, a Workcell Controller (WCC) of the CIM system will control the traffic flow using a "black box" approach to which the input and output of the SMEMA interface shall plug into. Removal of the SMEMA interface between the machine and the conveyor PLC will result in the "original CIM" mode of operation for traffic control of the PWA.
2. In the "CIM MPCL" mode the WCC will explicitly request the conveyor to be stopped as part of its WIP/Changeover transactions using the SMEMA interface. In "Original CIM" mode, the operation shall be executed without product stopping.
3. Once "CIM MPCL" is operational, running a cell in the "Original CIM" mode will require a signed deviation.

1.3 Physical Attributes of a Station

Each station on the line shall consist of the following pieces of equipment:

1. A Bar Code Reader at the input conveyor to read the PWA bar code while the PWA is still moving. The decoded data will be sent to the WCC PC via a serial connection. The details of how this data is received using a serial port, networks, etc. is left up to the design / prototype phase of the project.
2. The input and output conveyors are to be controlled by PLC's. Communications from the PLC to WCC PC will be "direct digital" using the SMEMA interface.
3. The WCC PC at the stations shall be a 486 PC or higher with a minimum of 16MB of Memory. It shall be networked to the other WCC PC's on the Manufacturing Line and the Factory Control System. The network backbone and file system is under review and will be finalized as part of the detailed design effort.
4. The WCC PC shall communicate with the local process machine using the machine interface port (if one is available). At minimum the interface is to support program select, start and stop. If this functionality is not present for any particular machine, the user interface will be so configured to allow the "messages" to go to the user instead.

1.4 Operational Overview of a Station

Each process machine station on the line shall deal with the following operational scenario:

1. A Bar Code Reader at the input conveyor will read the PWA bar code while the PWA is still moving. The decoded data is configured so that the WCC PC receives the data immediately (less than 0.1 seconds).
2. The WCC PC will have supervisory control over the SMEMA Interface which provides override and sensing capability. This gives the WCC PC the control to determine which signals to pass and which are to be held up based on the WIP and Changeover status of the station.
3. After successfully scanning each PWA, the "prior" step check shall be performed.

The checks include the following:

- Check that Prior Step has been accomplished. Note that the "prior" step for a PWA may be different for each type of PWA and that its "route" data needs to be accessible by the "prior" step function.

- Check that the PWA is not on a “hold” status. A unit may be on a hold status due to a number of reasons including QA Hold, Unacceptable number of component failures, or a product issue.
 - Once the Check is done, the PWA is “Wiped In” to the station with its time stamp noted (i.e. assuming no product changeover - this is discussed in detail below).
4. When a new product type is introduced at the "first" station on the line, the WCC PC should send a notification to the operator. This request for "OK to Proceed" will require a supervisory password. This will provide the opportunity to either accept or override the product changeover. Once the first station has been authorized to proceed with the changeover, all subsequent stations on the "route" shall be given advance notification that a product changeover is planned. In addition, when the product change over is accomplished at this station, the next station on the route shall get an "impending" changeover signal. This will allow the operator at that downstream station to prepare any product changeover items that will be necessary prior to PWA arrival, thus minimizing down time.
 5. To support product change over, the WCC PC will get all appropriate changeover data from the database. It will then validate the data with what is on the station. Appropriate user screens will allow the operator to validate that the product change over is complete. This validation shall be in the form of a check list displayed on the WCC PC, that will tell the operator items such as part programs, fixture/tooling changes, etc. that need to be completed. Where ever possible, these will be designed to be "verifiable", such as bar coding or clicking the appropriate box.
 6. Once the PWA unit is ready to enter the station, the preferred method of starting program execution is for the WCC PC to notify the Machine which programs to download, select and execute. In a few circumstances this may not be possible due to the complexity of the machine interface. In that case the user will be prompted to “manually” load and start the appropriate program.
 7. Once the machine is finished with the PWA, it will use the SMEMA interface to provide the OK signal to release the PWA onto the output conveyor. Once the PWA is on the output conveyor, the SMEMA interface will “signal” the WCC PC that the PWA is on the output conveyor. The WCC PC will than get the time stamp and send out a Wip Out Transaction to update the database.
 8. In the event of feeder replenishment or changeover to a different component, the WCC PC will provide a mechanism to “validate” that the correct component part was placed in the correct feeder in the correct location on the machine. The details of this design shall be finalized in the design/prototype phase of the project.
 9. In the event that a station has been idle for a configurable period of time (~3 hours), a product changeover will be forced on the machine. This will allow for any maintenance or down time items to be purged and a valid production program be run.
 10. Component Consumption transactions will be handled using a set of the Manufacturing Bill of Material tables for each Operation with current sequences for machine locations. A component consumption application on the WCC PC will support updates to the databases with “trace” data.

1.5 Functional Overview of a Machine Interface

Each of the process machine stations on the line will have "interface drivers" that provides communications and functional support. The following machine types with their interface needs and functionality will be used by the MPCL Program.

1.6 Machine Types

1. MPM UP 3010 Screen Printer
2. Adhesive Dispensing Machine
3. Panasonic MV-II TopSide Chip Shooter
4. Universal GSM Ball Grid Array Placement Machine
5. Electrovert ATMOS 2000 Reflow Oven
6. Westkleen Cleaner
7. GenRad 2284 In-Circuit Tester Station
8. CenCorp TR4000 Depanelling Machine

1.7 Features / Functions List

1. Program Changeover by Product Change. Either due to new product or different product revision.
2. Product Verification and / or Changeover if the Station is "idle" for "X" time. Typically this time shall be about 3 hours.
3. Product Changeover on Initialization or Restarting of a Station.
4. As part of Product Changeover, need to verify that part feeder is loaded into the correct "slot" in the machine. This will also be supported where there are multiple "Z" (feeder carriages) axes with different "Sequence" codes.
5. Need to verify that "part" is scanned to correct feeder in an on-line or off-line mode
6. Routing Verification for each PWA is to include the unit being valid, not on Hold, not Scrapped, "X" number of fails through a station, and must be processed within a given amount of time from a previous station.
7. Machine and part data collection to be supported using the machine interface as much as possible.
8. Defect Data to be manually entered.
9. Traceability using product scanned at the station and parts scanned as discussed earlier with sequence codes for lot Traceability.
10. Advance and Immediate notification for product changeover to be based on routings, and not physical line stations.
11. System must support failover if the main Factory Control System database server goes down.
12. The WCC PC database server is to support transient data and be self maintaining. The data is to be "rolled" up and / or purged as the PWA is finished and completes the routing.

13. The User Interface at the machine stations will support multimedia files for support setup and build instructions.
14. The WCC PC will interface with the conveyor PLC using a SMEMA interface between the process machine and the conveyor. The WCC PC will be the overriding traffic controller.
15. Access to the FCS will be made available to the users via their desktop PC's.

Appendix 2 - Operational Scenarios

2. Operational Scenarios

For each station on the manufacturing line, the following provides a detailed Operation Scenario along with Issues and Assumptions. Issues in subsequent sections are not repeated, but will assume to be covered when first identified. In addition, general operational scenario related to "prior" step check and product changeover were discussed in Appendix 1. These will be briefly mentioned in the detailed scenarios to provide specific information related to that operation and to provide continuity.

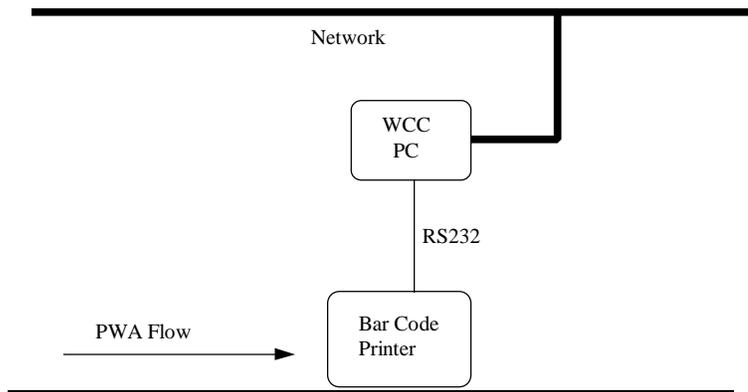
2.5 Bar Code Label Application Station

2.1.1 Overview

The Bar Code Label Application Station is where an operator generates Kapton labels that are applied to the PWA. Typically a PWA consist of two individual circuit card assembly's, with only one bar code on the breakaway to identify the PWA panel. These Kapton labels are applied to the PWA and stay with it until the Depanel Operation where individual labels on the circuit boards are used to track it and the breakaway is disposed of.

The station consists of the following:

- A WCC PC that interacts with the plant wide FCS system and the operator.
- A Bar Code Printer capable of printing Kapton Labels for PWA's. The interface between the WCC PC and the Printer is RS232 communications.



2.1.2 Operating Scenario

1. The Operator will determine which type of PWA and quantity to build on the line. Based on the list of valid units, the operator will print the appropriate number of PWA labels.
2. The User Interface screen shall support password protection so that only authorized operators may create the labels. Units are sequenced automatically by the Cell based on previous serial numbers. These numbers are to be Julian Date and Serial Number based along with a Product Identifier. The Cell shall provide the Operator with information as to what is a valid engineering build for the line.
3. Once the labels are defined, the WCC PC shall print the labels for the operator to place on the PWA. If the operator needs to print additional labels due to spoilage, they will be able to "re-print" them with the proper password.
4. The Production Planner will define the quantity scheduled to be built by day, by line and by Product Type. The Operator shall not be authorized to modify this.

2.1.3 Issues / Assumptions

1. The FCS application suite shall provide a Dispatch List of valid repetitive schedule and work orders along with a Valid List of Part Numbers / Product ID's and production priorities.
2. Verification of the bar code labels printed will be performed on a continuous basis. This shall be accomplished by having this cell be integrated with the next PWA board handler cell which will perform the validation prior to allowing the panels to move downstream.

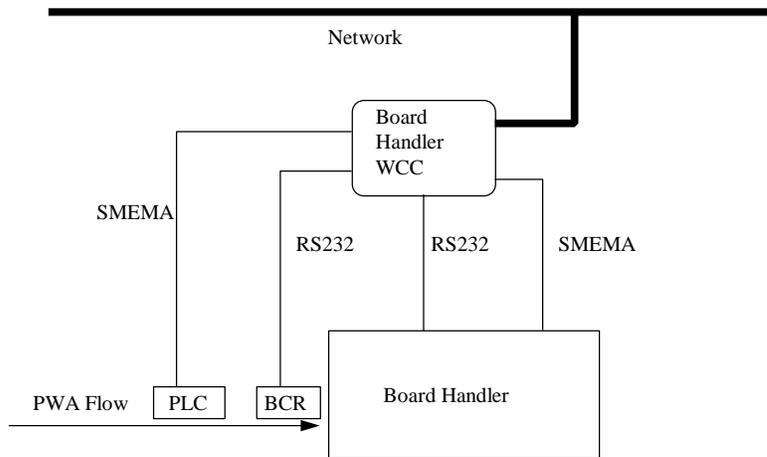
2.2 PWA Board Handling (Loader) Station

2.2.1 Overview

The Board Handling Station's purpose is to take the bare PWA's and put them on the conveyor. When downstream demand requests a PWA; they are released on to the output conveyor.

The station consists of the following:

- Automated Board Loader capable of loading a variety of PWA's.
- Supports PLC Communications using SMEMA interface.
- A Bar Code Scanner using a RS232 interface.



2.2.2 Operating Scenario

1. The Operator stacks a set of labeled PWA assemblies into the loader. The PWA Loader loads them on to the in-feed conveyor based on demand.
2. The Board Handler Controller based on downstream demand will release the boards onto the conveyor.
3. Exceptions shall be handled by the Board Handler Controller and a warning beacon shall be used to notify the Operator. Exceptions include No Read, Duplicated bar code, etc.
4. When a new product type is introduced at the "first" station on the line, the WCC PC will notify the operator that a changeover is at the first station. This request for "OK to Proceed" will require a supervisor password. This will provide an opportunity to either accept or override the product changeover.
5. Once the first station has been authorized to proceed with the changeover, all subsequent stations on the "route" shall give advance notification that a product changeover is planned. In addition, when the product change over is accomplished at this station, the next station on the route shall get an "impending" changeover signal. This will allow the operator at that downstream station to prepare for product changeover, thus minimizing setup down time.

2.2.3 Issues / Assumptions

1. Currently there is no interaction with the CIM System. It is a PLC controlled machine. It will be controlled using the SMEMA interface.
2. This station is to be "controlled" by the Barcode Label Application Station to support label verification.

3. This station will be the “first” station for “advance notification” function for changeover control
4. This station and the Barcode Label Application Station will use the same WCC PC and user display.
5. Advance "new" and "impending" notification is to be designed using a "route" line concept where each station will send to the next station downstream.

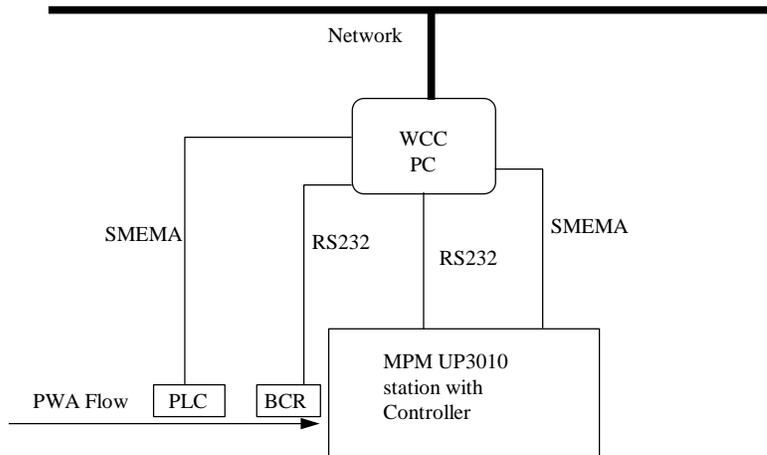
2.3 Screen Print (MPM UP 3010) Station

2.3.1 Overview

The Screen Print Station is used to screen (apply) solder paste to the bare PWA. The process typically consists of a fine steel screen held in a fixture assembly being positioned on top of the PWA. A vision system uses fiducials to accurately place the screen onto the PWA. Based on the program, the "squeegee" then kneads the solder paste and spreads it over the steel screen. The mesh in the steel screen allows only selected pad regions to receive the solder paste. Typically a vision system is then used to provide spot checking of certain key locations for correct solder paste adhesion. If the adhesion is not sufficient, an alarm is generated for operator intervention.

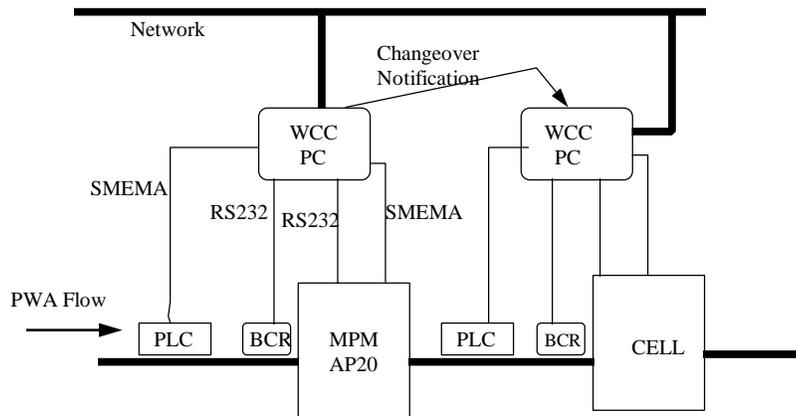
The station consists of the following:

- Semi-automatic MPM UP 3010 Screen Printer capable of a communications interface based on the SECS-I protocol over a RS232 port. The Message level functionality is proprietary to MPM and support Program Upload/Download, Program Select, and Program Complete Status.
- PLC Communications using the SMEMA interface and direct I/O to the MPM Controller.
- A WCC PC that interacts with the plant wide FCS system, machine controller and PLC.
- A Barcode Reader (BCR) that is positioned at the entry of the Cell with stop capability to provide WIP functionality and support.



2.3.2 Operating Scenario

1. The BCR is tripped by the PWA arriving, and resulting in the BCR scanning the bar code. At the same time this sensory trigger shall stop the conveyor from moving further. The scanned bar coded input shall be input in the WCC PC.
2. The WCC PC receives this bar code and starts a series of checks on the PWA including valid PWA, correct current location, work order is OK to process, if unit is OK to process, and if change over is needed for the cell.
3. Exceptions shall be smartly handled by the WCC PC as discussed in section 2 and if Operator attention is required, it shall so be requested.
4. If no changeover is needed, the WCC PC will direct the PLC using the SMEMA interface with an OK to Release and the PLC will release the PWA onto the input conveyor of the process machine.
5. When the PLC releases the PWA onto the input conveyor of the process machine, an event will be generated by the WCC PC that the PWA has been released. This will result in the WCC PC time stamping the WIP-IN time for the particular unit. It will then update the FCS database with this data.
6. To support product change over, the WCC PC validation shall include:
 - Bar Coded Screen Fixture.
 - Program to run which validates the Screen with matching fiducials.
 - Solder Paste Changes, or kneading.



2.3.3 Issues / Assumptions

1. We are going to be using bar code readers with fast / wide scanning to support on the fly scanning.
2. Assumption is that the master controller in "releasing" the PWA into the Cell is the PLC. Overriding traffic control is to be provided by the WCC PC using the SMEMA interface.
3. The data on the items necessary for product change over are to be entered in the Configuration Management System of the FCS as individual data items as well as a check list of manufacturing instruction that will be displayed.
4. How involved should the "verification" be for supporting product change over? Simple with dependence on operator as central controlling link, or Constrained with minimal dependence on operator, and all operator work being "verified"? Assumption is this level of effort is being evaluated for addressing the feeder verification.

2.4 Adhesive Dispensing Station

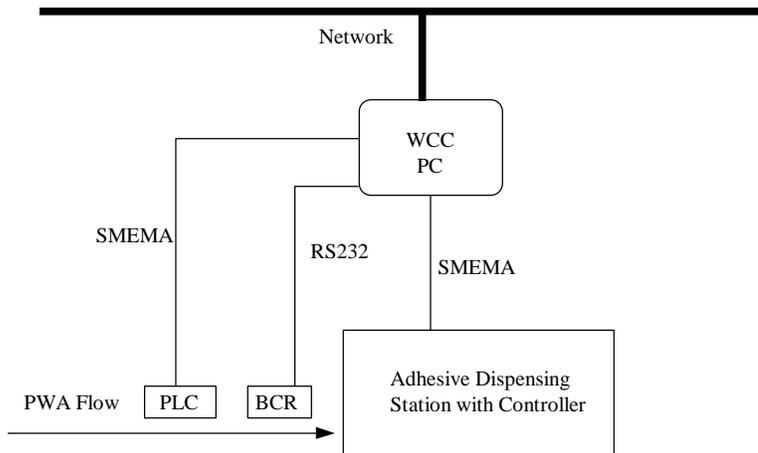
2.4.1 Overview

The Adhesive Dispensing Station's role is to apply beads of adhesive on the PWA so that the bottom side surface mount components may bond to the PWA. These than get wave soldered later in the process to achieve the electrical bonding.

The station consists of the following:

- Adhesive Dispenser capable of Program upload / download, Select and Start.
- PLC Communications using a SMEMA interface and direct I/O to the Adhesive Dispensing Station with Controller.

- A WCC PC that interacts with the plant wide FCS system, the machine controller and PLC.
- A BCR that is positioned at the entry of the Cell with stop capability to provide WIP functionality and support.



2.4.2 Operating Scenario

1. Same basic set of operating scenario as the earlier sections. Changeover data from the database includes:
 - Program to run.
 - Adhesive and / or nozzles changes, if any.

2.4.3 Issues / Assumptions

1. Should the Screen Printing and this Adhesive Dispensing Station be one and the same, with the WCC PC supporting the two separate operations? Would this be better for the user, or keep it simple with one WCC PC per Machine Station? For now it will be kept separate.
2. The Sony Adhesive Machine interface document was not available, need to verify what type of machine communications it supports?

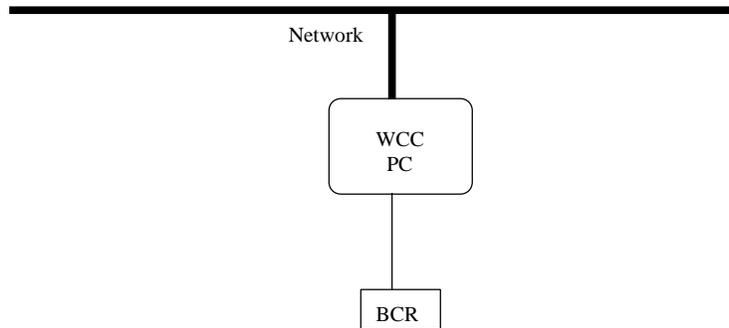
2.5 Inspection Station

2.5.1 Overview

The Inspection Station is a manual station. In this station an operator inspects the PWA's for defects such as solder paste defects, adhesive placement defects, etc. These defects are noted into the defects database using a graphical interface, and the appropriate touch up is done. Depending on the throughput, there may be more than one station performing this operation.

The station consists of the following:

- A WCC PC based that interacts with the plant wide FCS system and operator.
- A BCR to provide WIP functionality and support.



2.5.2 Operating Scenario

1. The PWA barcode is scanned. The system will perform all the WIP checks that it would normally do for a PWA on the line. Any exception condition will be brought to the operators attention.
2. If the PWA status is OK, the operator will inspect the PWA and enter any defects using the defects data collection application. The operator will than be given the option to PASS or FAIL the PWA. If the PWA failed it will be removed for rework. If it passed, the operator will release the PWA for further processing.
3. Using this interface the operator will have the option of seeing the trend and pareto charts of defects.

2.5.3 Issues / Assumptions

1. Should this station be considered part of the route? It is assumed yes, and that we have 100% inspection.
2. It is assumed that the current Real Time Feedback System will be used, with the possible enhancement of hitting the relational database. In addition, is the system to roll up all the defects data into the RDBMS for long term trending and capability analysis?

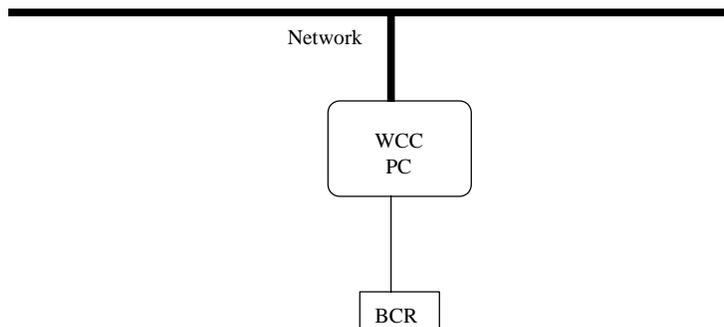
2.6 Off-line Reel Loader Station

2.6.1 Overview

The Off-line Reel Loader Station is a manual station. In this station an operator loads the part reels onto the respective feeders.

The station consists of the following:

- A WCC PC based that interacts with the plant wide FCS system and operator.
- A BCR to provide WIP functionality and support.



2.6.2 Operating Scenario

1. The part reels Part Number and Lot Number barcodes are scanned. The system will perform all the WIP and valid part checks. Any exception condition will be brought to the operators attention.
2. If the PWA and part status is OK, the operator shall load the part reel onto the feeder. The operator will then scan the Part Number, Lot Number and Feeder Number.

2.6.3 Issues / Assumptions

1. Should this station be considered part of the route? It is assumed yes, and that we have 100% inspection.

2.7 Fine Pitch Chip Shooter (MV-II) Station

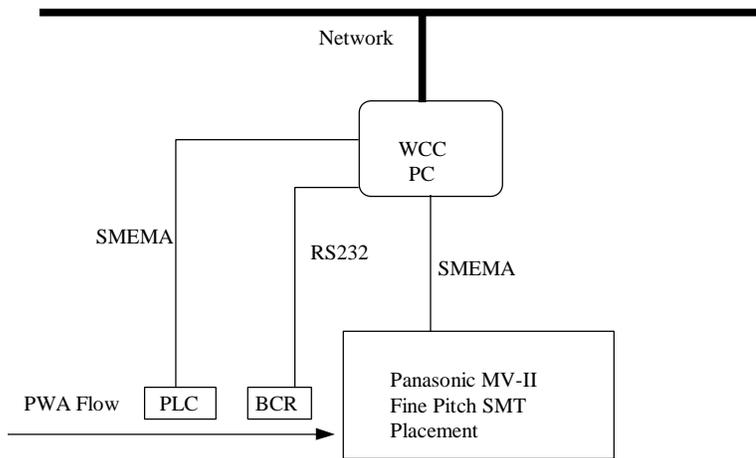
2.7.1 Overview

The Fine Pitch Chip Shooter generally put on the active components such as large Pin Grid Arrays, ASICs and custom chips that have better than 50mil pitch requirements. They generally have a

vision system that verifies component placement using fiducials to provide the higher accuracy needed to place the fine pitch components.

This station consists of the following:

- Automatic Panasonic MV-II SMT Standard Surface Mount Placement Machine capable of Program Select, and Program Complete Status. The interface supported by this station is "proprietary" and using ACK/NAK handshake with checksum.
- PLC Communications using a SMEMA interface and direct I/O to the MV-II Controller.
- A WCC PC that interacts with the plant wide FCS system, the MV-II controller and PLC.
- A BCR that is positioned at the entry of the Cell with stop capability to provide WIP functionality and support.



2.7.2 Operating Scenario

1. Same basic set of operating scenario as the earlier sections. Changeover data from the database includes:
 - Program to run.
 - Any components and /or feeder types to be changed.
 - Any component pick up nozzles changes.

2.7.3 Issues / Assumptions

1. Advance notification will be handled by these downstream stations. There is to be no mechanism to respond to the "notifying" stations that this particular stations is able to get ready for the pending changeover.

2. How should the Manufacturing Bill of Materials concept be developed and implemented at these stations? How should the validation be performed when there are "component" parts that need to be changed? How to address the need for "sequence" number changes as new parts are used to replenish used components? This effort being evaluated.

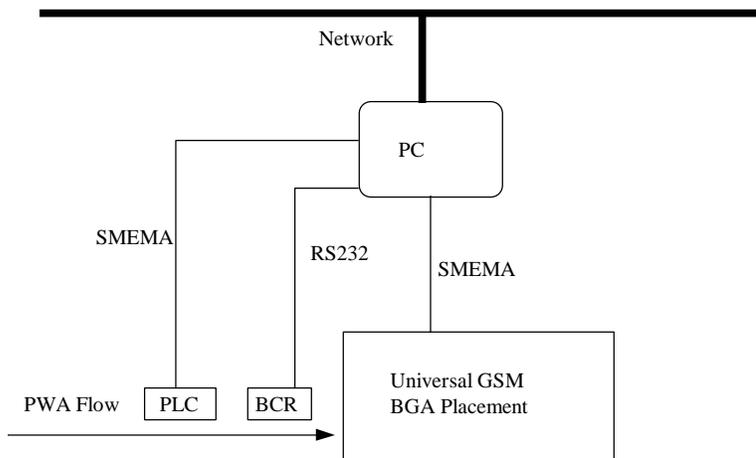
2.8 Ball Grid Array - Top Side Placement (Universal GSM) Station

2.8.1 Overview

The Ball Grid Array (BGA) technology is relatively new, and this machine will place BGA packages on the PWA. They generally have a vision system that verifies the placement using fiducials to provide the higher placement accuracy needed to place the BGA components.

This station consists of the following:

- Automatic Universal GSM Surface Mount Placement Machine capable of Program Select, and Program Complete Status. The interface supported by this station is "proprietary" and using ACK/NAK handshake with checksum.
- PLC Communications using SMEMA interface and direct I/O to the Universal GSM Controller.
- A WCC PC that interacts with the plant wide FCS system, the Universal controller and PLC.
- A BCR that is positioned at the entry of the Cell with stop capability to provide WIP functionality and support.



2.8.2 Operating Scenario

1. Same basic set of operating scenario as the earlier sections. Changeover data from the database includes:

- Program to run.
- Any components and / or feeder types to be changed.
- Any component pick up nozzles changes.

2.8.3 Issues / Assumptions

1. Is there any time period that needs to be used to trigger an event for the time between solder placement and the final component placement? The assumption is that this is a general capability and is configurable by station as part of some station data or route data.

2.9 Inspection Station

2.9.1 Overview

The Inspection Station is a manual station. In this station an operator inspects the PWA's for defects such as, solder paste defects, adhesive placement defects, etc. These defects are noted into the defects database using a graphical interface, and the appropriate touch up is done. Depending on the throughput, there will be more than one station performing this operation. Details of this station type are discussed in section 4.5 above.

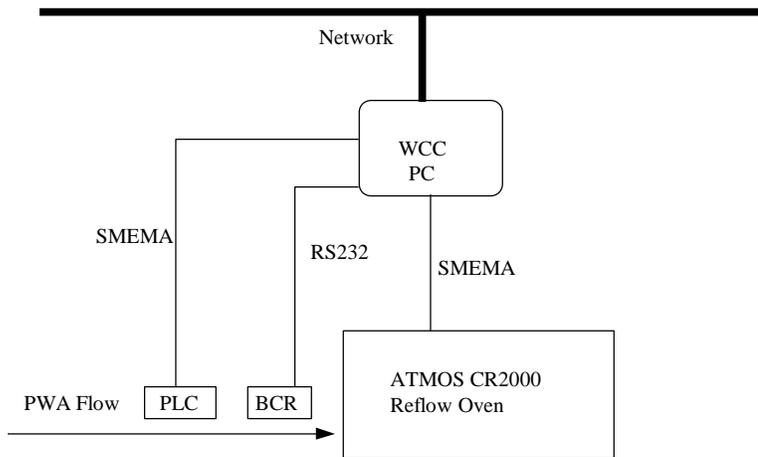
2.10 Reflow Oven (Electrovert ATMOS CR2000) Station

2.10.1 Overview

The Reflow Oven provides the hot forced air curing for the solder paste to provide the electrical bond for the top side components. It also cures the adhesive and solder paste on the bottom side components.

The station consists of the following:

- ATMOS CR2000 Reflow Oven capable of Manual Program Select and Run. The interface supported by this station is "proprietary" and using ACK/NAK handshake with checksum.
- PLC Communications using SMEMA interface and direct I/O to the ATMOS Controller.
- A WCC PC that interacts with the plant wide FCS system and PLC.
- A BCR that is positioned at the entry of the Cell with stop capability to provide WIP functionality and support.



2.10.2 Operating Scenario

1. Same basic set of operating scenario as the earlier sections. Changeover data from the database includes:
 - Program Name only.

2.10.3 Issues / Assumptions

1. Assumption is that the Time of Solder Paste Screening and this Reflow time is to be monitored at WIP-IN to allow for Operator Override if too much time has elapsed. Don't believe that the Data Model has this functionality in it. Need to design a way to handle this requirement.

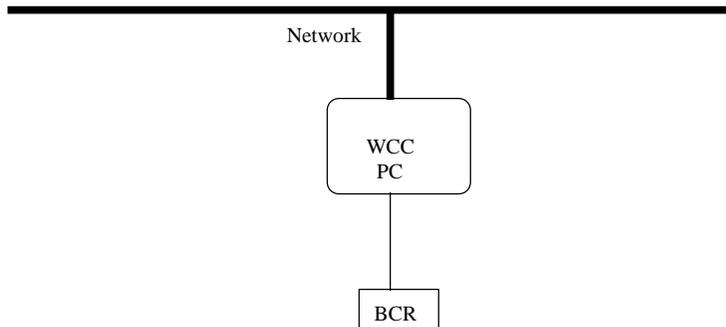
2.11 Inspection / Touch Up Station

2.11.1 Overview

The Inspection / Touch Up Station is a manual station. In this station an operator inspects the PWA's for defects such as missing components, mis-oriented components, solder defects, cleaning defects, etc. These defects are noted into the defects database using a graphical interface, and the appropriate touch up is done. Depending on the throughput, there will be more than one station performing this operation.

The station consists of the following:

- A WCC PC that interacts with the plant wide FCS system and operator.
- A hand held BCR to provide WIP functionality and support.



2.11.2 Operating Scenario

1. The Operator picks up the PWA and scans the bar code. The system will perform all the WIP checks that it would normally do for a PWA on the line. Any exception condition will be brought to the operators attention.
2. If PWA status is OK, the operator will inspect the PWA and enter any defects using the defects data collection application. The operator will than be given the option to PASS or FAIL the PWA. If the PWA failed it will be removed for rework. If it passed, the operator will place it back on the conveyor for further processing.
3. Using this interface the operator will have the option of viewing, storing or printing the trend and pareto charts of defects.

2.11.3 Issues / Assumptions

1. The station is to be capable of adding or replacing “components”. To support this the user interface will need to have a mechanism to “add” a new component with a date lot sequence code.
2. Should this station be considered part of the route? It is assumed yes, and that we have 100% inspection.
3. It is assumed that the current Real Time Feedback System will be used, with the possible enhancement of hitting the relational database. In addition, the system to roll up all the defects data into the RDBMS for long term trending and capability analysis.

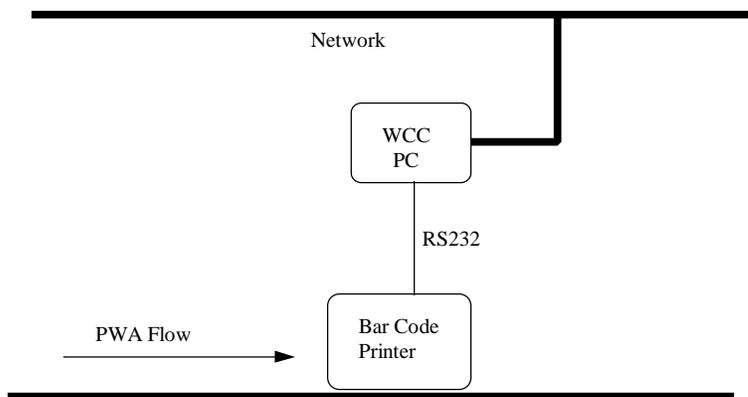
2.12 Board Label Application Station

2.12.1 Overview

The Board Label Application Station is where an operator generates Polyester labels that are applied to the individual Circuit Boards that make up a PWA. These labels are used for tracking after the Depanel operation.

The station consists of the following:

- A WCC PC that interacts with the plant wide FCS system and the operator.
- A Bar Code Printer capable of printing Polyester Labels for Circuit Boards. The interface between the WCC PC and the Printer is RS232 communications.



2.12.2 Operating Scenario

1. The operator will print the appropriate number of Circuit Board labels.
2. The User Interface screen shall support password protection so that only authorized operators may create the labels. Units are sequenced automatically by the Cell based on previous serial numbers. These numbers are to be Julian Date and Serial Number based along with a Product Identifier.
3. Once the labels are defined, the WCC PC shall print the labels for the operator to place on the Circuit Board. If the operator needs to print additional labels due to spoilage, they will be able to "re-print" them with the proper password.

2.12.3 Issues / Assumptions

1. Verification of the bar code labels printed will be performed on a continuous basis.

2. This station may be combined with the previous Inspection / Touch Up Station.

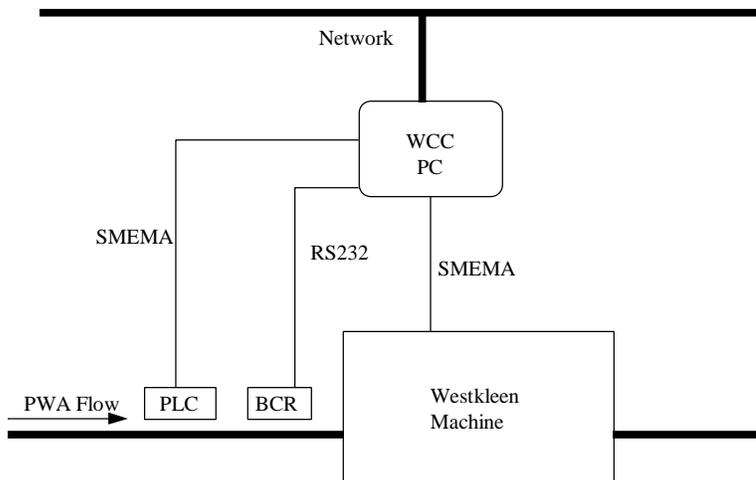
2.13 Wash (Westkleen) Station

2.13.1 Overview

The Wash Station provides the aqueous cleaning necessary to remove the residue that is a result of the solder paste curing process.

This station consists of the following:

- Westkleen PWA Wash Machine capable of Manual Program Select and Run. The interface supported by this station is "proprietary" and using ACK/NAK handshake with checksum.
- PLC Communications using SMEMA interface and direct I/O to the Westkleen Controller.
- A WCC PC that interacts with the plant wide system and PLC.
- A BCR that is positioned at the entry of the Cell with stop capability to provide WIP functionality and support.



2.13.2 Operating Scenario

1. Same basic set of operating scenario as the earlier sections. Changeover data from the database includes:
 - Program Name only.

2.14 Issues / Assumptions

1. Is there a real need to have multiple recipes with this station. In most cases one should be able to use only a single recipe and not need changeover. Recommendation is that no interface be designed for this as in most cases only one recipe will be necessary.

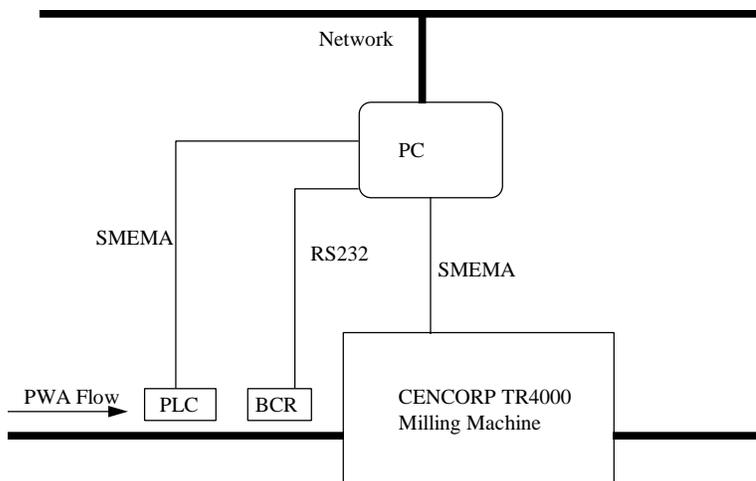
2.15 PWA Depanel Station

2.15.1 Overview

The PWA Depanel Station is used to remove the individual circuit cards that ride in a panel chassis. The individual cards are held to the panel by tabs that are left in place as part of the panel creation. When these tabs are machined out, the individual circuit cards are separated and the Kapton labels are added to the individual cards.

The station consists of the following:

- CENCORP TR4000 Milling Machine. The interface supported by this station is "proprietary"
- PLC Communications using SMEMA interface and direct I/O to the CENCORP Controller.
- A WCC PC that interacts with the plant wide FCS system and PLC.
- A BCR that is positioned at the entry of the Cell with stop capability to provide WIP functionality and support.



2.15.2 Operating Scenario

1. Same basic set of operating scenario as the earlier sections. Changeover data from the database includes:
 - Program Name
 - Depanel Fixture
2. The operator then depanels the circuit cards out of the panel.

2.15.3 Issues / Assumptions

1. Do we want to consider total manual fixture changeover or do we want to investigate automatic fixture changeover? The assumption is that this will be a manual changeover for MPCL PWAs.

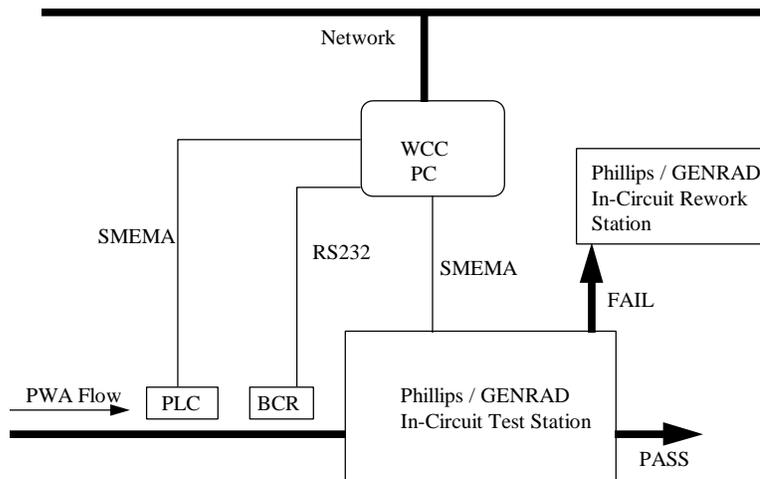
2.16 In-Circuit (GENRAD) Station

2.16.1 Overview

The In-Circuit Station provides the electrical tests needed to verify that the individual circuits are good and that there are no solder related problems that could cause electrical malfunction. If a PWA unit fails the test, it is manually routed to a "rework" area for rework and repair. The fail data collected on the unit is provided to the diagnostic technician to isolate the problem and correct it.

The station consists of the following:

- GENRAD In-Circuit Fixture Handling Station. The interface supported by this station is "proprietary" and using ACK/NAK handshake with checksum. Other details are unknown.
- GENRAD In-Circuit Test Computer. Interface to the Test Data collection is place and uses RS232.
- PLC Communications using SMEMA interface and direct I/O to the GENRAD Controller.
- A WCC PC that interacts with the plant wide FCS system and PLC.
- A hand held BCR with stop capability to provide WIP functionality and support.



2.16.2 Operating Scenario

1. Same basic set of operating scenario as the earlier sections. Changeover data from the database includes:

- Program Name
 - In-Circuit Test Fixture
2. The in-circuit tester performs the test on the PWAs and when it is done with the assembly, it will alert the operator that the test passed and further processing can continue. If the PWA failed, it will alert the operator that the test "FAILED" using the PC cell controller and ask for the PWA to be removed for rework.

2.16.3 Issues / Assumptions

1. Are we to perform any data collection from the test station. If yes, is this data to be only fail data or all data? How do we want to handle detail test step value and test limits? For the purpose of MPCL, we are to only collect status; test data will be collected as done currently.
2. The assumption is that this will be a manual changeover.
3. What level of test data collection will be made available to the rework test technician on line? Is this real-time? The assumption is yes to both based on the existing/planned test data collection automation that is being done outside of the MPCL Program. No additional work is being proposed as part of MPCL.

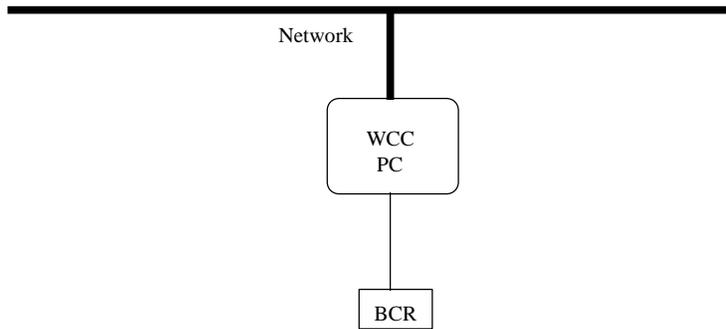
2.17 Core Bond Station

2.17.1 Overview

The Core Bond Station is a manual assembly station. In this station an operator takes two PWA's and bonds them over a heat sink, back to back. This results in one assembly being formed from two PWA.

The station consists of the following:

- A WCC PC that interacts with the plant wide FCS system and operator.
- A hand held BCR to provide WIP functionality and support.



2.17.2 Operating Scenario

1. The Operator picks up the PWAs and scans the bar code. The system will perform all the WIP checks that it would normally do for a PWA on the line. Any exception condition will be brought to the operators attention.
2. If the PWA status is OK, the operator will than core bond the two PWAs and enter the data into the system through the user interface provided. This station will provide the necessary user interaction to have one PWA become the “parent” assembly, while the second one becomes the “child” assembly.
3. Using this interface the operator will have to option of seeing work instructions for how to perform the assembly.

2.17.3 Issues / Assumptions

1. The station is to be capable of creating a higher level assembly and a child assembly from two PWA’s. To support this the user interface will need to have a mechanism to “mate” the two PWA’s together. From here on down, the “parent” PWA will only need to be WIPed, and all the data is for that PWA. The child PWA goes along for the ride.

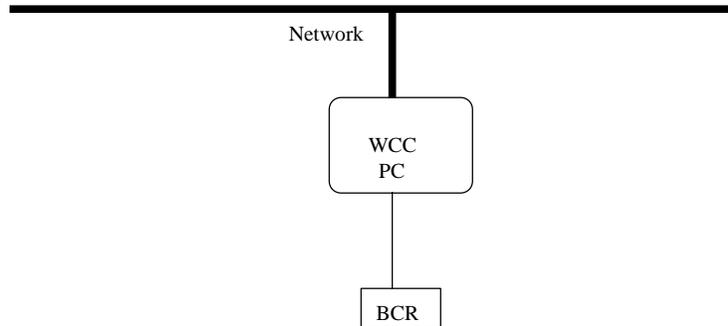
2.18 Hot Bar Station

2.18.1 Overview

The Hot Bar Station is a manual solder assembly station. In this station an operator taken two PWA’s that are assembled and solders one end with a connector for the preparation of the flex cable attachment.

The station consists of the following:

- A WCC PC that interacts with the plant wide FCS system and operator.
- A hand held BCR to provide WIP functionality and support.



2.18.2 Operating Scenario

1. The Operator picks up the PWA and scans the bar code of the “parent” PWA. The system will perform all the WIP checks that it would normally do for a PWA on the line. Any exception condition will be brought to the operators attention.
2. If the PWA status is OK, the operator will then hot bar the connector in preparation for the flex cable.
3. Using this interface the operator will have the option of viewing work instructions for performing the assembly.

2.18.3 Issues / Assumptions

The station should be capable of determining the correct WIPed PWA, if the child is Wiped instead of the “parent”. This will simplify the users job of wandng either of the serial numbers.

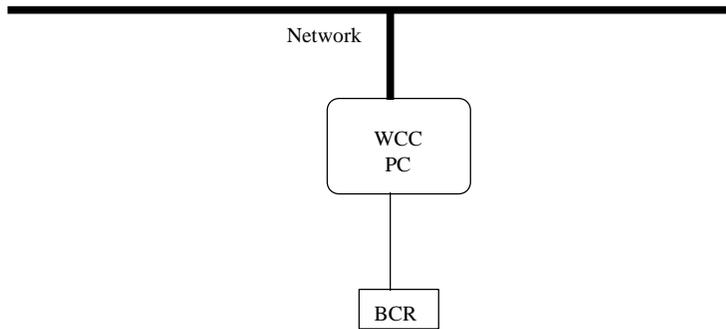
2.19 Flex Attach Station

2.19.1 Overview

The Flex Attach Station is a manual cable assembly station. In this station an operator taken two PWA’s that are assembled together and attaches the flex cable assembly to them.

The station consists of the following:

- A WCC PC that interacts with the plant wide FCS system and operator.
- A hand held BCR to provide WIP functionality and support.



2.19.2 Operating Scenario

1. The Operator picks up the PWA and scans the bar code of the “parent” PWA. The system will perform all the WIP checks that it would normally do for a PWA on the line. Any exception condition will be brought to the operators attention.
2. If the PWA status is OK with both the PWA’s, the operator will than attach the flex cable.
3. Using this interface the operator will have to option of seeing work instructions for how to perform the assembly.

2.19.3 Issues / Assumptions

1. The station should be capable of determining the correct WIPed PWA, if the; child is WIPed instead of the “parent”. This will simplify the users job of wandng either of the serial numbers.

2.20 Inspection / Touch-Up Station

2.20.1 Overview

The Inspection / Touch-Up Station is a manual inspection and rework station. At this station an operator inspects the PWA’s for defects such as the quality of assembly of the Core Bond, Hot Bar and the Flex Attachment processes. Defects are noted into the defects database using a graphical interface, and the appropriate touch up is done. Depending on the throughput, there may be more than one station performing this operation. Details of this station type are discussed in section 4.10 above.

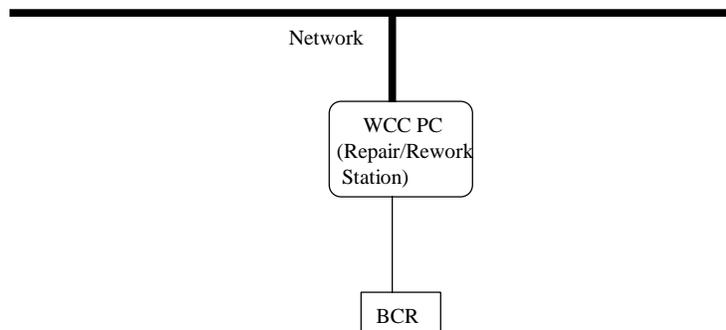
2.21 Repair Station

2.21.1 Overview

The Repair Station provides the diagnosis and rework for all PWA's that failed the in-circuit test as well as any inspection identified defects from the manual assembly. The test failure or defects data collected on the unit is provided to the diagnostic technician to isolate the problem and correct it. This data may be on paper or available electronically. This repair station will be in a common area, and not be part of a "line".

The station consists of the following:

- A WCC PC that interacts with the plant wide FCS system and operator.
- A hand held BCR to provide WIP functionality and support.



2.21.2 Operating Scenario

1. The station should be capable of determining the correct WIPed PWA, if the; child is WIPed instead of the "parent". This will simplify the users job of wandng either of the serial numbers.
2. The operator will bring up the test / diagnostic data for the PWA and perform all the necessary rework to it.
3. Using this interface the operator will have to option of viewing, storing or printing the trend and pareto charts of test results.
4. At the rework station the test technician shall diagnose the problem and provide the necessary corrective action to fix the problem. They will then route the PWA back to the sending station for retest.

2.21.3 Issues / Assumptions

1. At this station the operator shall have the capability to add or replace “components”. To support this, the user interface will need to have a mechanism to “add” a new component with a date lot sequence code.
2. The existing method of trend reporting will be extended to provide for real time feedback of paretos, trending, etc.

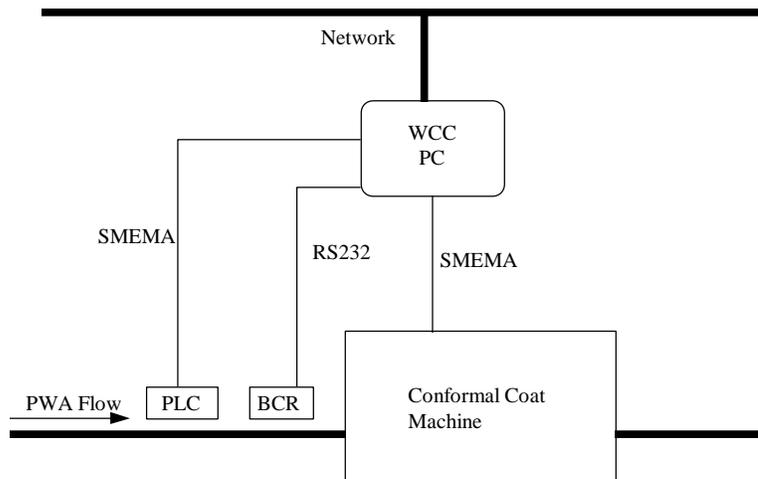
2.22 Conformal Coat Station

2.22.1 Overview

The Conformal Coat process consists of putting a fine layer of an acrylic or varnish based coating that cures either through heat or UV light. This coating protects the circuit from foreign growth and protection from moisture and other electrical containment's.

The station consists of the following:

- “ITI” Conformal Coat Station. The interface supported by this station is "proprietary".
- PLC Communications using SMEMA interface and direct I/O to the Conformal Coat Controller.
- A WCC PC that interacts with the plant wide FCS system and PLC.
- A BCR to provide WIP functionality and support.



2.22.2 Operating Scenario

1. Same basic set of operating scenario as the earlier sections. Changeover data from the database includes:

- Program Name
- Coating substance if different

2.22.3 Issues / Assumptions

1. Is there a real need to have multiple recipes with this station. In most cases one should be able to use only a single recipe and not need changeover. Same recommendation as cleaner.

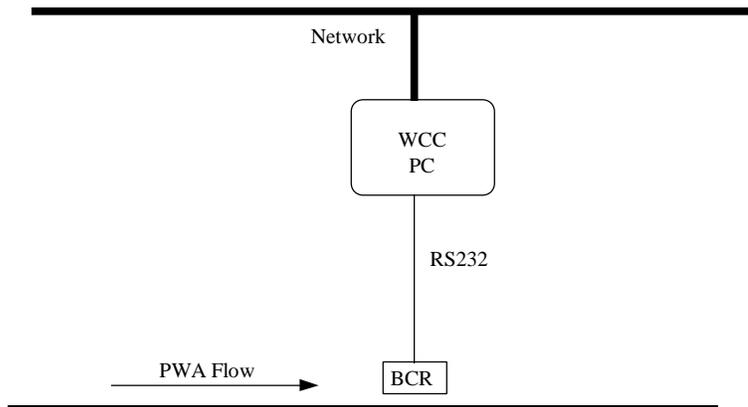
2.23 Final Assembly Station

2.23.1 Overview

The Final Assembly process consists of putting the final mechanical packaging around the PWA to make it a complete unit. This typically consists of fastening hardware and some shell that wraps around the PWA (if applicable).

The station consists of the following:

- Manual Station where final assembly takes place using hand tools and work instructions as to what is needed to put the PWA into a final assembly.
- A WCC PC that communicates with the plant wide FCS system and the operator.
- A BCR to provide WIP functionality and support.



2.23.2 Operating Scenario

1. The Operator picks up the PWA and scans the barcode. The PC performs a validation check on WIP and other aspects of the unit such as all the tests are completed, that there are no outstanding issues against the unit and that it is ready for final assembly.
2. The PC then brings up the appropriate work instructions as how to assembly the PWA into a final assembly with call outs for all appropriate tooling and part lists needed at this operation.
3. After the unit is completed the Operator will “finish” the assembly and WIP Out the unit.

2.23.3 Issues / Assumptions

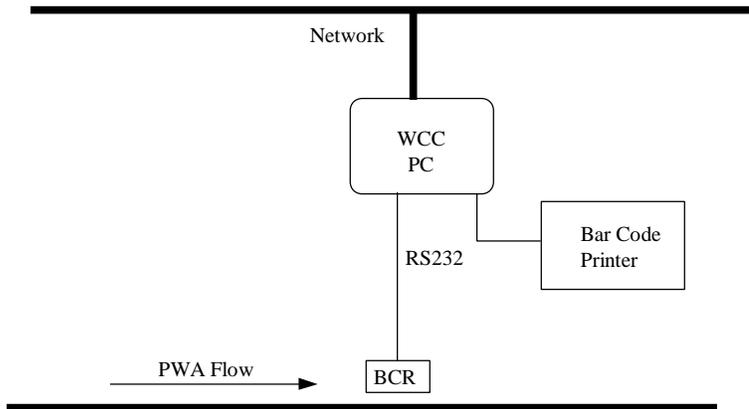
1. The station should be capable of determining the correct WIPed PWA, if the child is WIPed instead of the “parent”. This will simplify the users job of wandng either of the serial numbers.
2. The work instructions are to be graphical and / or textual.

2.24 Pack and Ship Station

2.24.1 Overview

The Pack and Ship Station consists of the following:

- Manual Station where Packing and Shipping takes place using normal packing and shipping materials.
- Instructions describing what to pack into what boxes and how.
- A WCC PC that interacts with the plant wide FCS system and operator.
- Bar Code Printer to print packing labels for either individual or multi-unit boxes.



2.24.2 Operating Scenario

1. The Operator picks up the PWA and scans the barcode. The WCC PC performs a complete validation check on WIP, Defects / Test and Bill of Material History to determine if the unit has completed all necessary steps in the production process prior to this point. It will also determine if there are no outstanding issues against this unit or for the work order that it belongs to.
2. The WCC PC brings up the appropriate work instructions for packing the final assembly with call outs for all appropriate boxes, bar code printouts etc. needed at this operation.
3. After the unit is completed the Operator will “finish” the assembly. The system will close out the unit and put it in finished goods inventory. The system shall also roll up transient data for that unit into summary tables so that the server database is self maintaining.

2.24.3 Issues / Assumptions

1. 100% “auditing” is required to validate that the Unit has completed its route and that there are no outstanding items left for this unit to complete prior to shipping.
2. The Shipping / Receiving System shall determine how the unit is packed, what boxes it should go into and where it should be shipped to. This is outside of the scope of the CIM portion of the line?
3. “Palletizing” function is to be supported outside of the CIM System.

Appendix 3 – CIM System Design Description

3. CIM System Design Description

The method used in documenting the design process includes providing a high level design description of each of the sub-subsystem along with a modular “sub-system dataflow” diagram that delineates the type and level of support expected from each module within a sub-system. These modules, and their respective functions are defined in Figure 3-1 below.

Legend for Dataflows

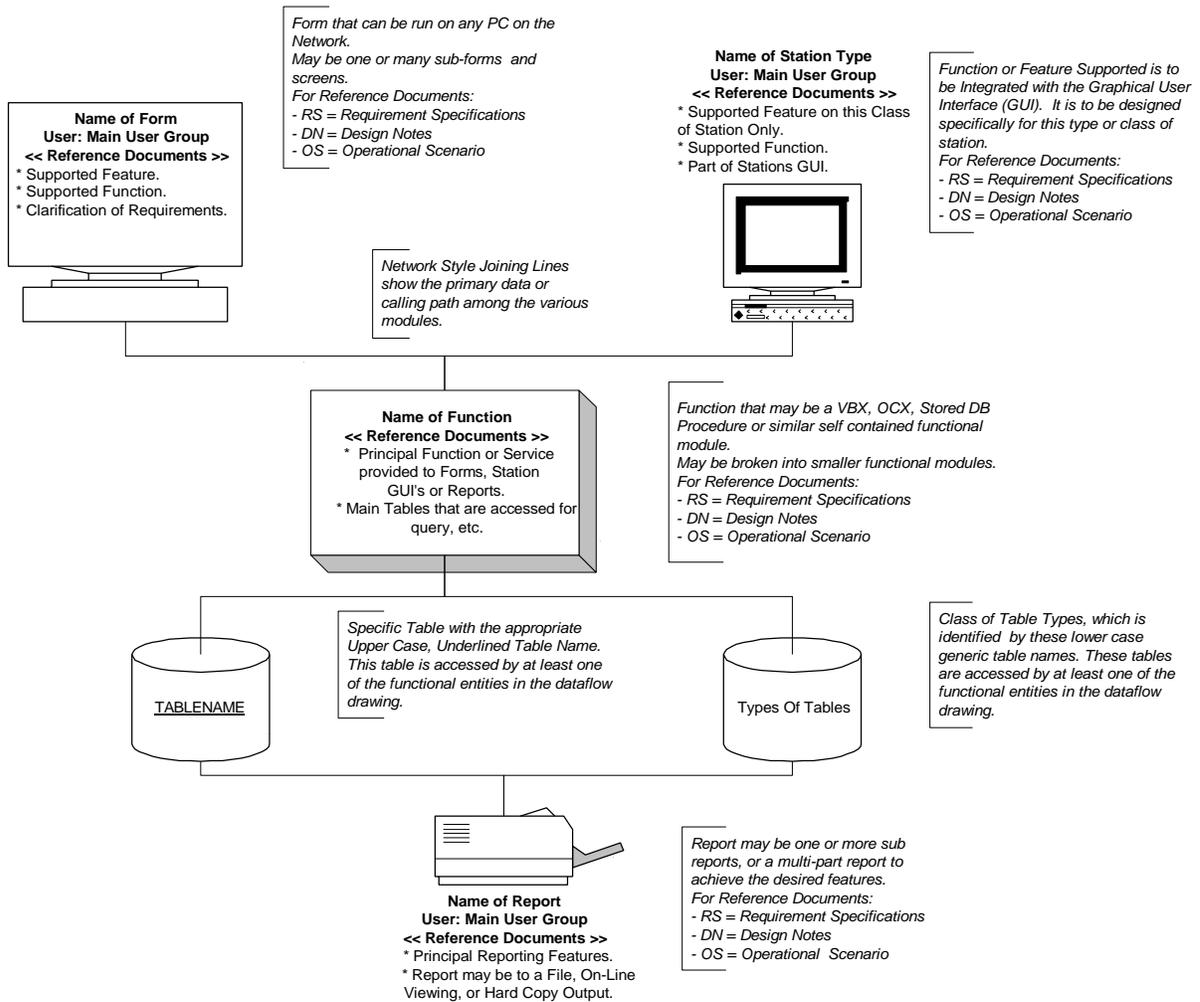


Figure 3-1.

In addition, included are the major “user based dataflows” that represent how these modules are to be used to meet the requirements deliverables. These modules include Generic User Forms that can run on any user station, User Screens at Machine Stations that are specific to a particular or class of machine, Functional Modules that perform some processing activity that needs to be specifically addressed in the distributed architecture, Database Tables that provide the repository for the CIM Data and Reports that can be viewed on line, printed or written to a file for review or used by an external systems.

The CIM System Design description is separated into Factory Control System (FCS) sub-systems and Work Cell Controller (WCC) sub-systems. In general WCC sub-systems receive their configuration and reporting support from the FCS, but the main transaction load is on the WCC level.

The following are the FCS sub-systems:

- Factory System Configuration (FCS)
- Bill of Materials (BOM)
- Configuration Management (CM)
- Quality Model (QM)
- Repetitive Scheduling / Work Order Management (WOM)
- Production Reporting (PR)
- Archive / Dearchive (ARC)

The following are WCC sub-systems:

- Work In Process (WIP)
- Production Changeover (PCO)
- As Build Traceability (ABT)
- Alarm Management (AM)

The detail design discussion for each of the sub-systems is given below, while the major user based dataflows are discussed in Appendix 4.

3.1 Factory System Configuration (FSC) Design Description

The main function of the FSC sub-system is to provide basic plant configuration data to set up the factory. Prior to any production activity or development of product build definitions, the base CIM System had to be identified. FSC provides this through user forms that support the maintenance of plant tables, user authorization, factory operations, manufacturing locations and slot to machine relationships. These are discussed in detail in the RS document.

The major design goals include:

- FSC shall define the operation types, operation descriptions, and their relationship. For example, Operation 110 is of Operation Type Top Side Surface Mount.
- FSC shall define manufacturing locations of production equipment and stations and their relationships to operations. For example, Mfg. Location Panasonic MV-II-1 is of Operations 110.
- FSC shall define slot locations and their relationships to manufacturing locations. For example, MV-II-1 has 100 slots numbered MV-II-1-001 to MV-II-1-100.
- FSC shall provide the capability to maintain user password and relationships among users, user groups, and user qualifications. For example, User John Doe belongs to group Line1Shift1Group and has authorization to only perform Operation 110.

Figure 3-2 below is the dataflow diagram which shows major design modules for this sub-system.

Factory System Configuration (FSC) Dataflow

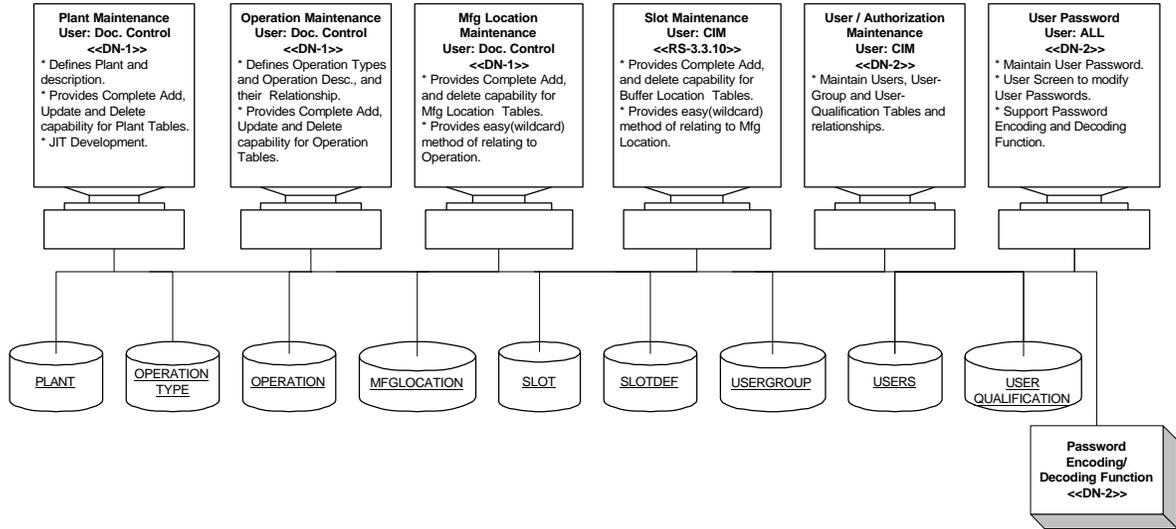


Figure 3-2.

3.2 Bill Of Material (BOM) Design Description

The main function of the BOM sub-system is to provide all the necessary BOM information along with product and process related data to support the manufacturing process. In this regard, the BOM sub-system supports the maintenance of the Manufacturing BOM (MBOM) which is derived from the Engineering BOM (EBOM), the quick generation of part list substitution, and the interface to Product Data Management (PDM) system and Material Management System (MMS). To achieve this a number of functional elements have to be made available. These are discussed in detail in the RS document.

The major design goals include:

- BOM shall maintain single level product structure for both EBOM and MBOM.
- BOM shall provide the capability to quickly generate new revisions of a parts list to run a substitute part when the planned part is not available.
- BOM shall support the interface to download an EBOM from the PDM system and validate parts against the Item Master provided by MMS.
- BOM shall support the interface to download the Item Master from MMS and access the MMS feeder / bin locations.
- BOM shall support on-line viewing of the MBOM and allow modification by authorized personnel.
- BOM shall provide a set of reports to provide single or multi level details of product and part usage by product and location.

Figure 3-3 is the dataflow diagram which shows major design elements for this sub-system.

Bill of Materials (BOM) Dataflow

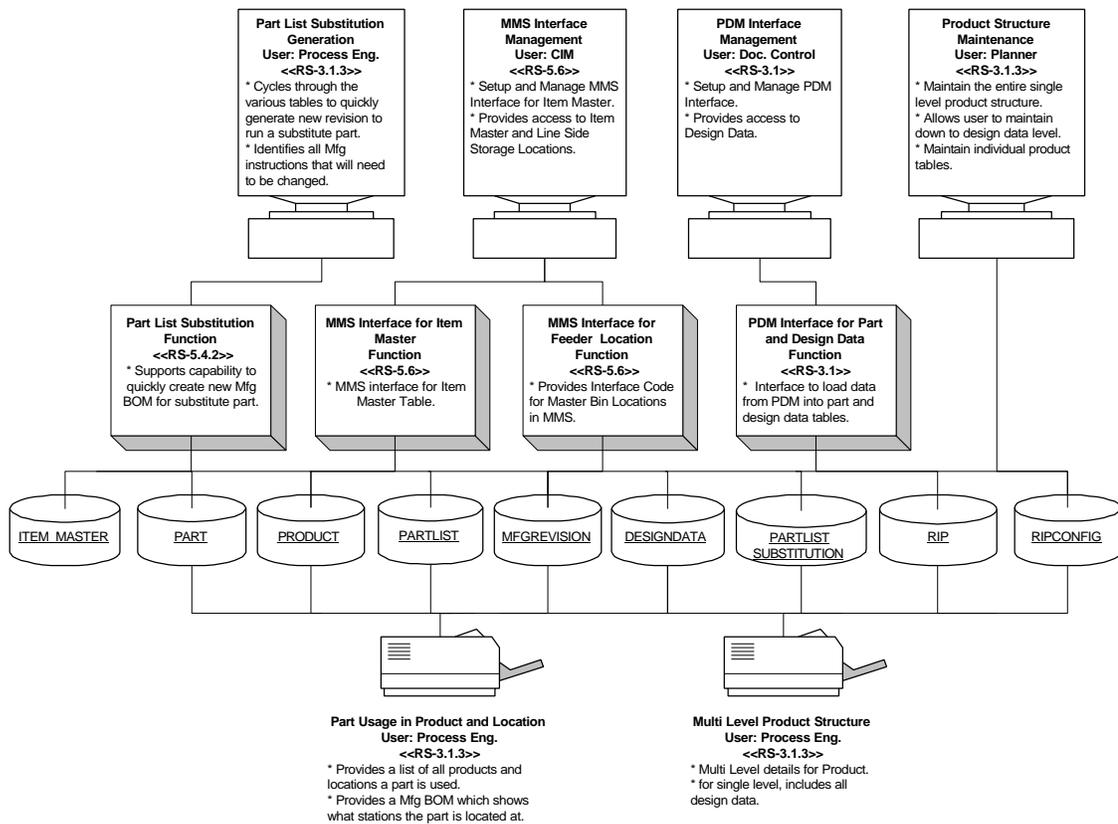


Figure 3-3.

3.3 Configuration Management (CM) Design Description

The main function of the CM sub-system is to manage the product configuration by part number, drawing, parts list and manufacturing revisions. In this regard, CM supports the maintenance of all appropriate revisions, the maintenance of the build effectivity, and validation of product configuration. Figure 3-4 is the dataflow diagram which shows major design elements for this sub-system. To achieve this a number of functional elements have to be made available. These are discussed in detail in the RS document.

Configuration Management (CM)

Dataflow

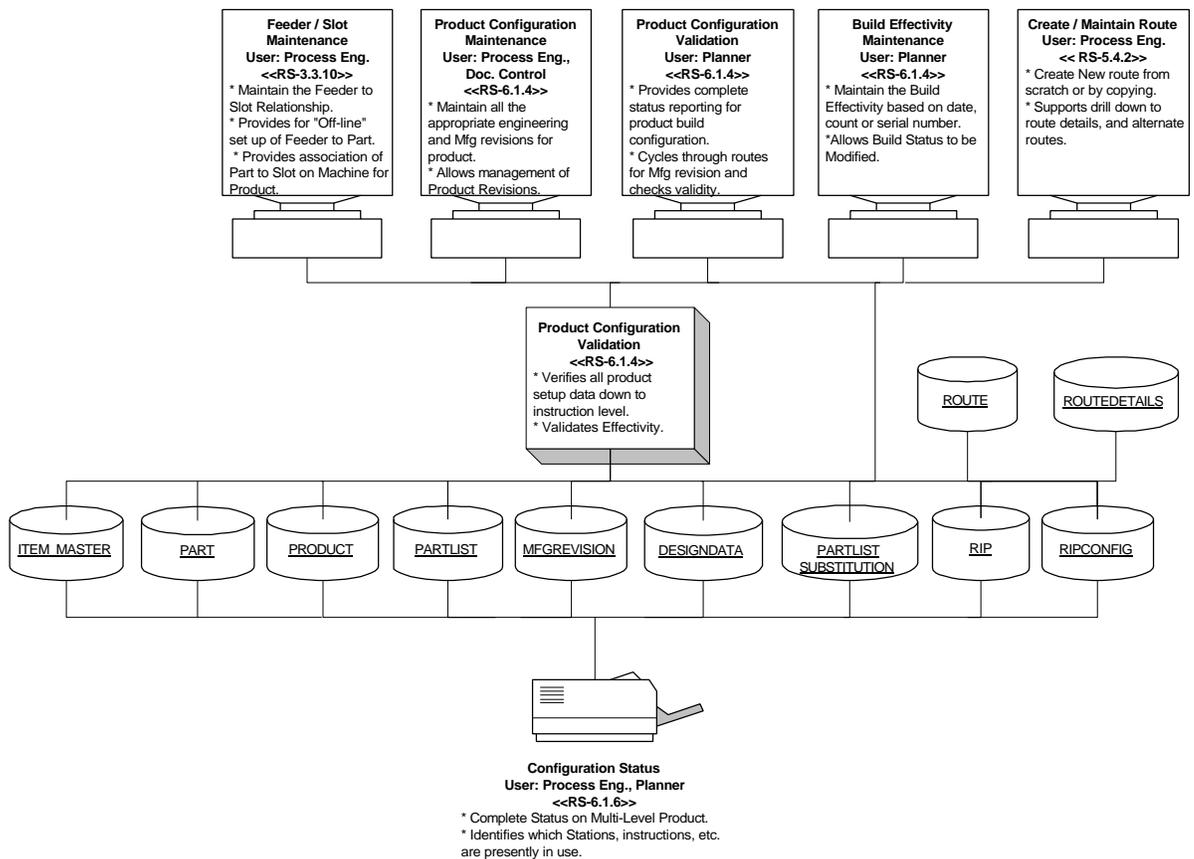


Figure 3-4.

The major design goals include:

- CM shall maintain all engineering and manufacturing revisions for the product and support modifications from authorized CM personnel.
- CM shall maintain build effectivity based quantity, date range or serial number range and support build status modification.
- CM shall maintain the process programs, instructions, etc. configuration by manufacturing revision and validate the status to be “production” before allowing them to be used for production.
- CM shall validate the repetitive schedule or manufacturing order generated by the FCS system against the build effectivity and status prior to releasing the order.
- CM shall define standard routing and optional routings for every product.
- CM shall provide a set of reports to provide the status and files or programs locations with appropriate revisions for a given product.

3.4 Quality Model (QM) Design Description

The main function of the QM sub-system is to allow new designs to be rated for their quality potential. Figure 3-5 is the dataflow diagram which shows major design elements for this sub-system. In this regard, QM uses the supplier, process quality along with process verification

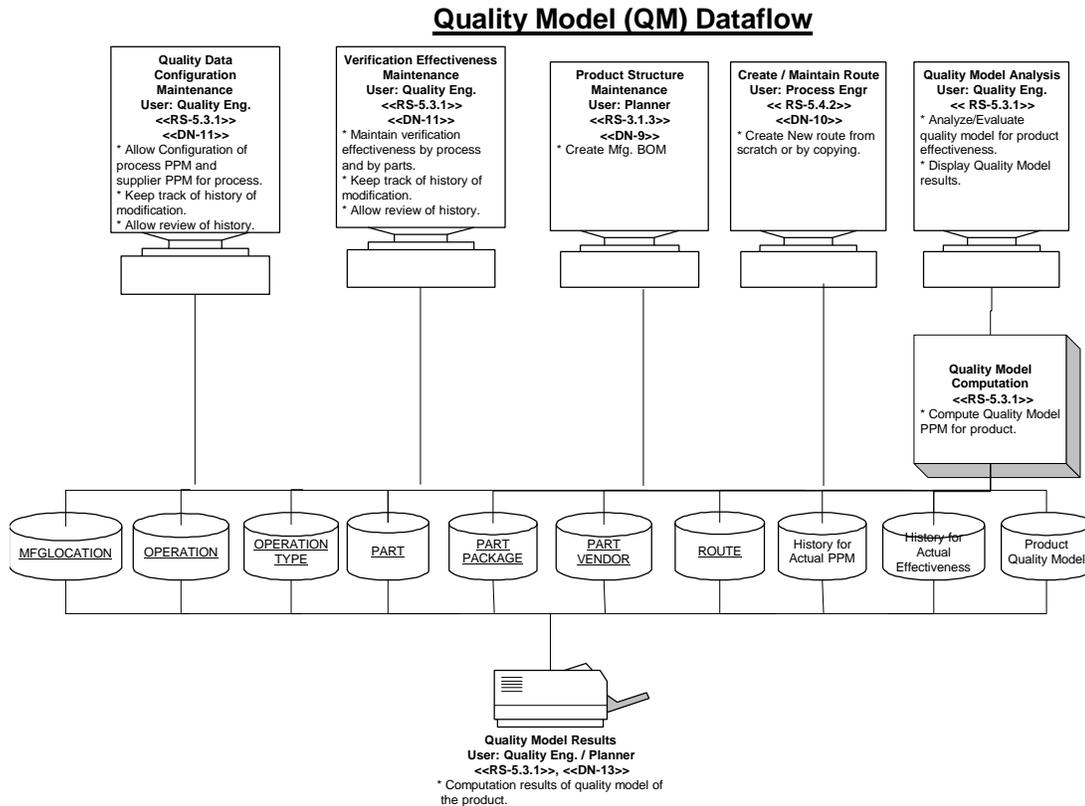


Figure 3-5.

effectiveness as input to compute the quality potential of the product. To achieve this a number of functional elements have to be made available.

The major design goals include:

- QM shall maintain parts-per-million (PPM) values for processes and supplier parts and history for PPM changes.
- QM shall maintain process verification effectiveness and history for effectiveness changes.
- QM shall compute and display the results of the product PPM based on PPM inputs of supplier parts, processes, and verification effectiveness.
- QM shall provide a set of reports to provide the results of the quality model PPM for the product.

3.5 Repetitive Scheduling / Work Order Management (WOM) Design Description

The main function of the WOM sub-system is to manage the building of product to the schedule or order for a selected product configuration. Figure 3-6 is the dataflow diagram which shows major

Repetitive Scheduling / Work Order Management (WOM) Dataflow

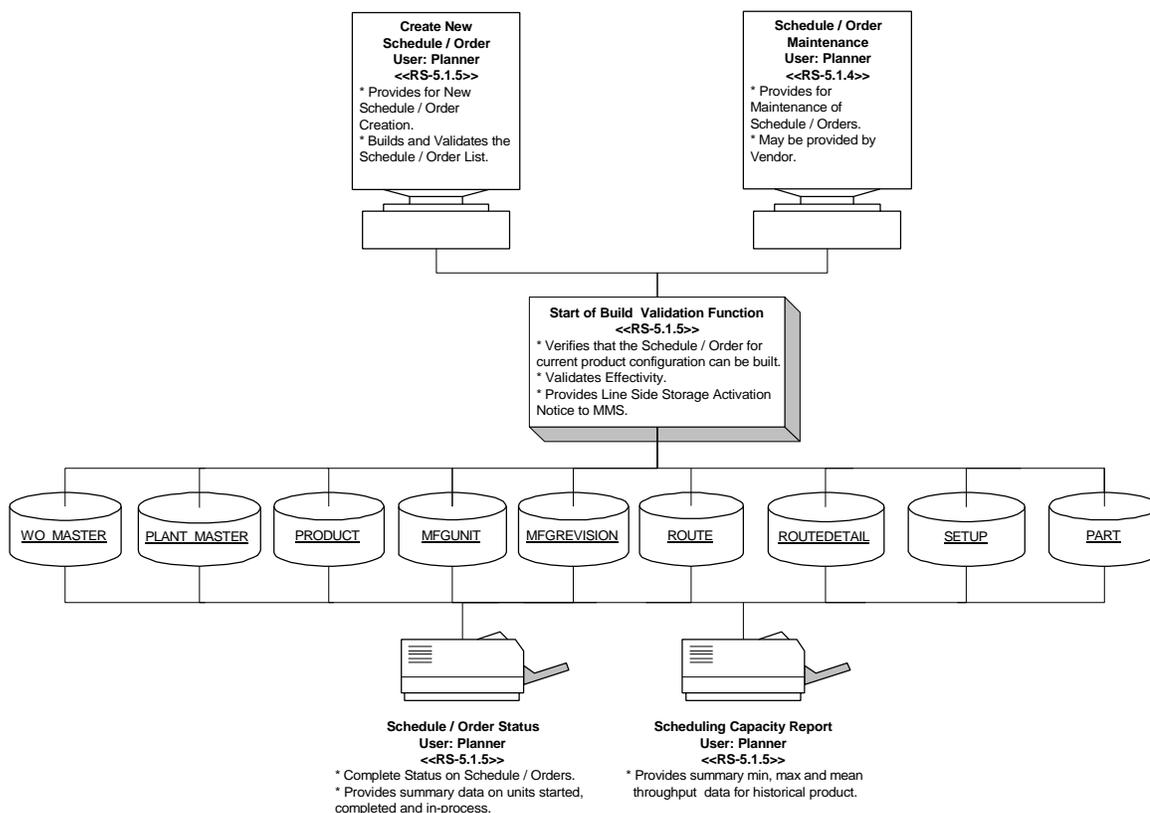


Figure 3-6.

design elements for this sub-system. To achieve this a number of functional elements have to be made available. These are discussed in detail in the MPCL CIM Requirements document.

The major design goals include:

- WOM shall provide the capability to create a new schedule and validate that the schedule can be built.
- WOM shall also validate the schedule against the configuration effectivity and flag any discrepancies to the planner.
- WOM shall provide reports for complete status on the schedule, such as units started, completed and in-process.

3.6 Production Reporting (PR) Design Description

The main function of the PR sub-system is to provide a number of “standard” reports to support management of the production process. In this regard, PR supports “shift” configuration and maintenance, reports of production yields, work in process (WIP), and production cycle time. To achieve this a number of functional elements have to be made available. These are discussed in detail in the RS document. Figure 3-7 above is the dataflow diagram which shows major design elements for this sub-system.

The major design goals include:

- PR shall define and configure “shifts” and Usergroups operations associated with each “shift”.

- PR shall support the capability to send “shift” change event notice to any station on the route.
- PR shall provide WIP reports that show the total number of WIP transactions performed during each shift.
- PR shall provide Production Yield reports that show yield, scrap, rejects, etc. at each station by shift.
- PR shall provide Production Cycle Time reports that show average, high, low and downtime, blocked time for each of the operations and products of the shift.
- PR shall provide the capability to view the complete history of any assembly at any station. History information such as defective components, repairs made, and test results for the assembly shall be included.
- PR shall support the archiving of shift data that can later be de-archived for analysis in a relational database.

Production Reporting (PR)
Dataflow

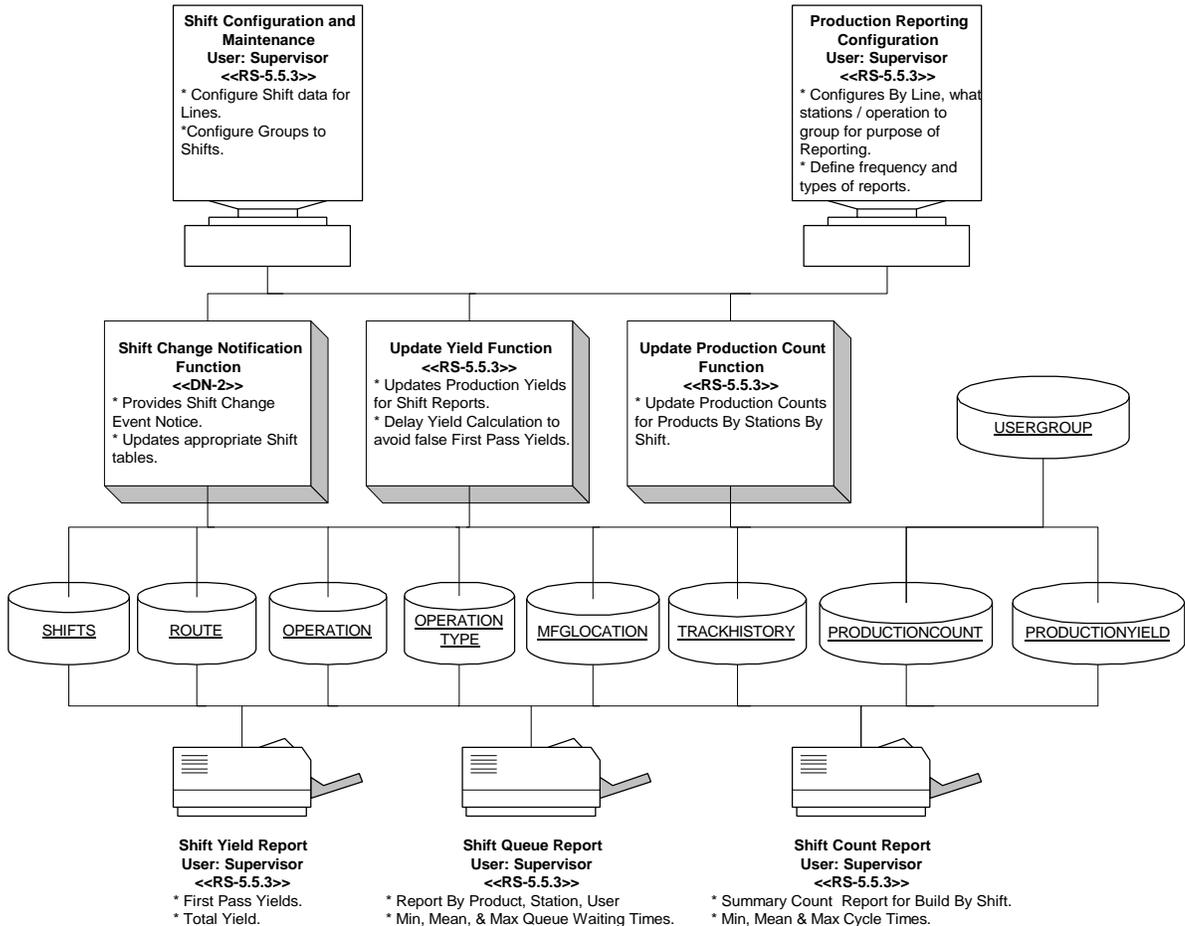


Figure 3-7.

3.7 Archive / Dearchive (ARC) Design Description

The main function of the Archive / Dearchive (ARC) Sub-System is to provide the capability of archiving and dearchiving all the relevant system data. In this regard, ARC supports the archiving and dearchiving of WIP, Trace, Product, Factory and Event data for review and analysis using a relational database. In addition, the capability to clear the data from the line database is essential. To achieve this a number of functional elements have to be made available. These are discussed in detail in the RS document and appendix.

The major design goals include:

- ARC shall support the self maintenance of WIP, Trace, and Event Data from the Line Databases when the unit being produced has been completed or shipped.
- ARC shall provide the capability to archive all unit (WIP, Trace and Event), product and factory data at regular interval with the capability to identify that this data has been archived.
- ARC shall support the archiving of data in a compressed format that can be later be decompressed and analyzed in a relational database.
- ARC shall provide dearchiving capability, without requiring that the dearchiving be done into the same structure tables as the original.
- ARC shall provide complementary sets of reports to provide the status and location of all archived data.

Figure 3-8 is the dataflow diagram which shows major design elements for this sub-system.

Archive / Dearchive (ARC) Dataflow

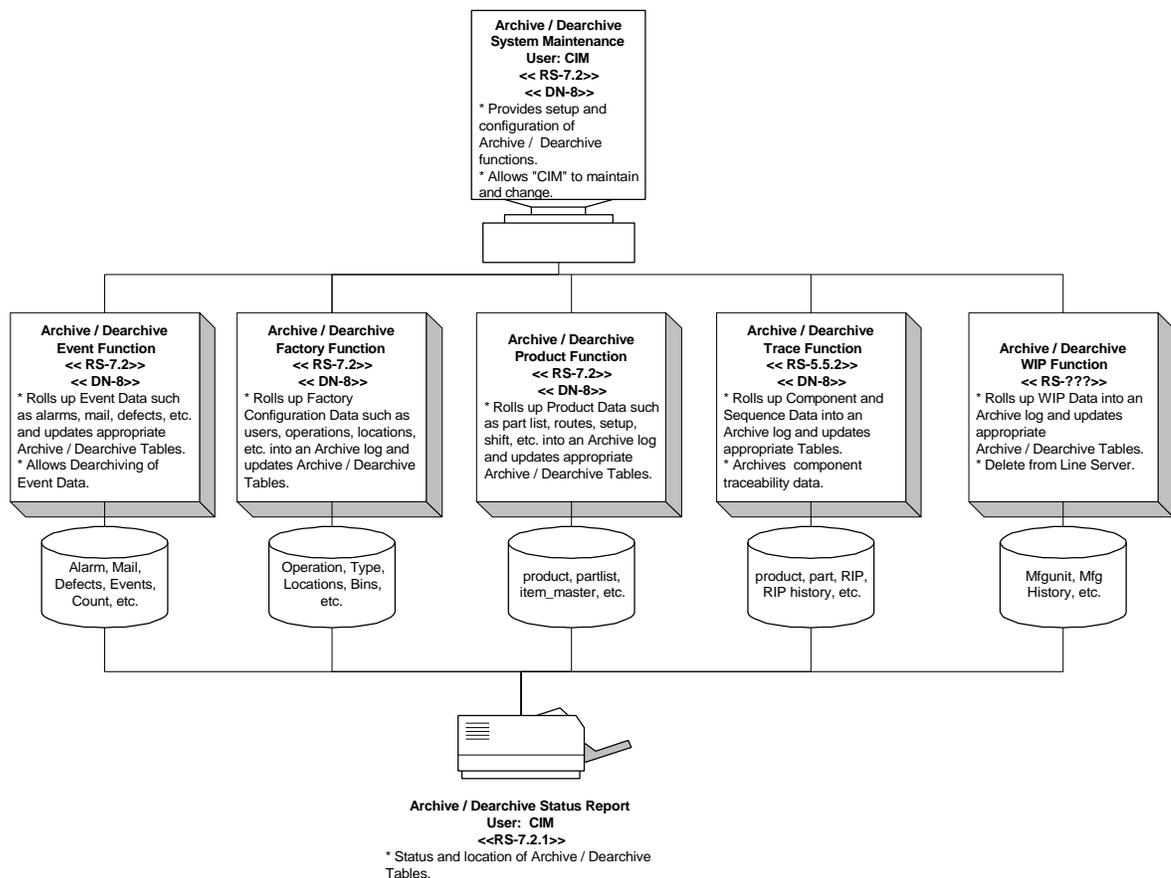


Figure 3-8.

3.8 Work In Process (WIP) Design Description

The main function of the Work In Process (WIP) Sub-System is to provide the capability to validate that every unit manufactured goes through its prescribed route. In this regard, WIP supports the control and tracking of PWA units on the route. To achieve this a number of functional elements have to be made available. These are discussed in detail in the RS document.

The major design goals include:

- WIP shall verify that the unit is at the correct location based on its route.
- WIP shall determine that the unit is not in a “hold” condition.
- WIP shall provide the measurement of time to process a unit through each station.
- WIP shall provide the capability to "transfer" a unit from its "base" route to an "alternate" route (i.e.: a special “repair” function or engineering evaluation).
- WIP shall provide a function that will place a unit or range of units on “hold”.
- WIP shall support an authorized person to change the Status or Location of a Unit.
- WIP shall support the reporting of unit history with time, station and user data.

Figure 3-9 is the dataflow diagram which shows major design elements for this sub-system.

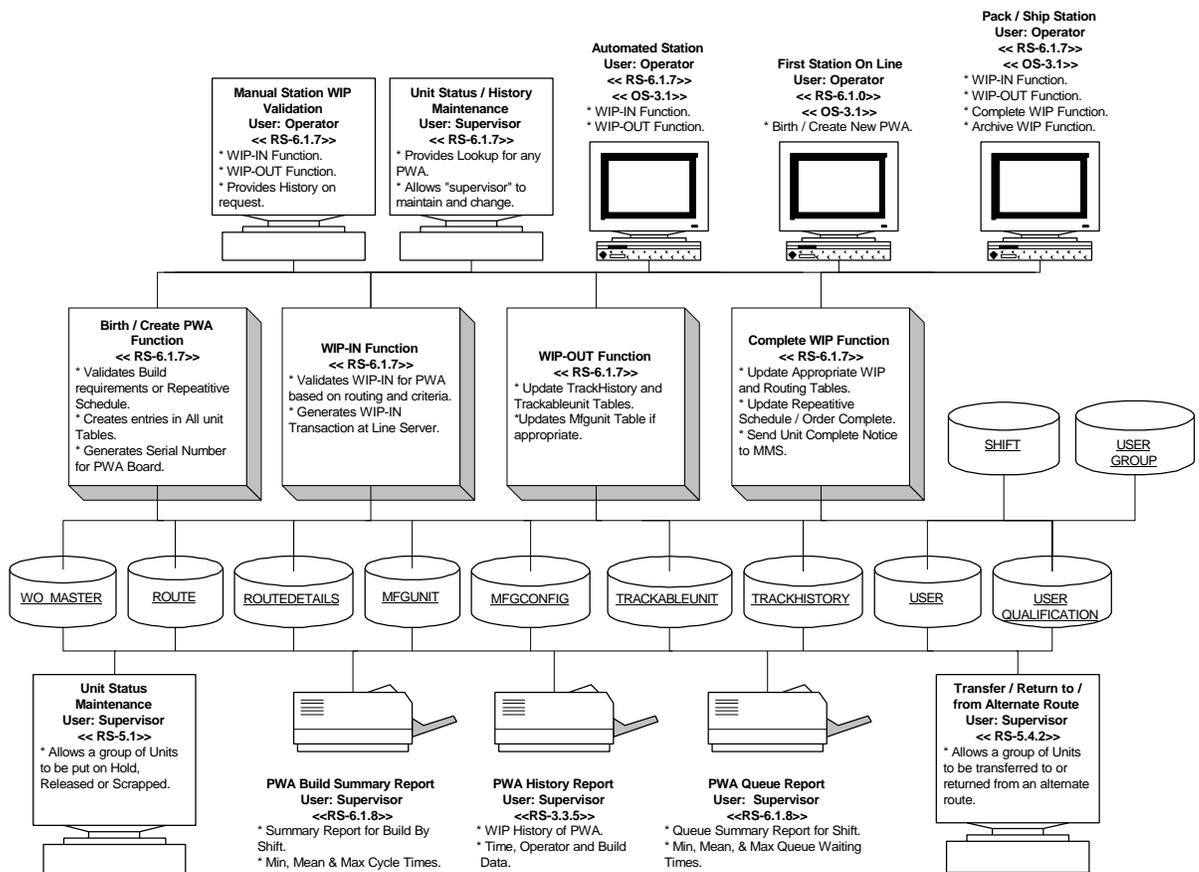


Figure 3-9.

3.9 Product Change Over (PCO) Design Description

The main function of the Product Changeover (PCO) Sub-System is to provide the capability to simplify and/or automate the changeover of part programs, component parts, fixtures and any instructions needed to build a new product at a station different from the one currently being produced. In this regard, PCO supports the status and the control of Station Configuration. To achieve this a number of functional elements have to be made available. These are discussed in detail in the RS document.

The major design goals include:

- PCO shall verify if changeover is needed for any product entering the cell that is different than the previous one.
- PCO provide advance notification to downstream stations that a new product has been introduced upstream.
- PCO shall support operator to determine the difference in component parts, feeders, fixtures and instructions for a new product.
- PCO shall provide features to validate that a product changeover is successful. This may include automatic part program download (or operator prompted download), verification of parts in appropriate feeders and slots, and a checklist of manual changes.
- PCO shall provide for feeder data to be extracted from part programs.
- PCO shall provide for on-line storage areas to be monitored by a material management system for automatic part replenishment.
- PCO shall provide a complete set of forms and a graphical user interface for performing changeover at a manual station.
- PCO shall support the maintenance of the next serial number.
- PCO shall provide complementary sets of reports to verify the setup of each and every station that a product is to travel to.

Figure 3-10 is the dataflow diagram which shows major design elements for this sub-system.

3.10 As Built Traceability (ABT) Design Description

The main function of the As Built Traceability (ABT) Sub-System is to provide the capability to track all component parts along with their sequence codes or serial number down to the lowest manufactured level. In this regard, ABT supports the collection and reporting of the complete as built product structure. In addition, it also provides for the capability that in the event a certain sequence code of a component part has been deemed prone to failure and requires further action, ABT shall support identifying all products along with their unique serial number that have it. To achieve this, a number of functional elements have to be made available. These are discussed in detail in the RS document.

Product Change Over (PCO) Dataflow

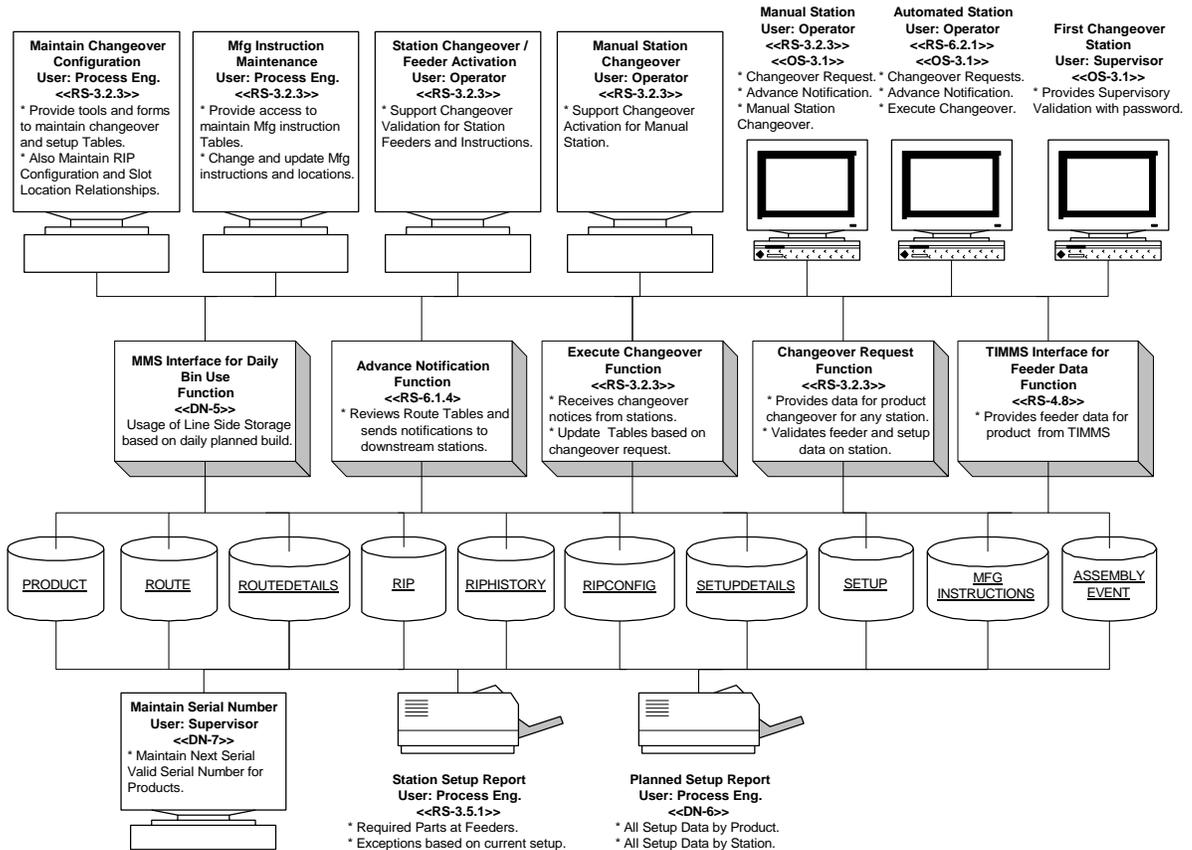


Figure 3-10.

The major design goals include:

- ABT shall support collection of sequence codes for all feeders at a station for a given time period.
- ABT shall provide the capability to validate that a product uses certain component parts from each of the stations in the route for the given product.
- ABT shall support operator to change part sequence codes in a feeder or slot when replenishment is necessary. In addition, it will support off-line feeder setup.
- ABT shall provide the capability to “insert” serialized components or sub-assemblies into higher level assemblies, with complete traceability.
- ABT shall provide the capability to compute component consumption for each station and provide this data to an external material management system.
- ABT shall provide the capability to determine what high level products contain a component part with a particular sequence code or lower level assembly serial number.
- ABT shall provide a complementary set of reports to provide the as built component part list with sequence codes or serial numbers for all products.

Figure 3-11 above is the dataflow diagram which shows major design elements for this sub-system.

As Built Traceability (ABT) Dataflow

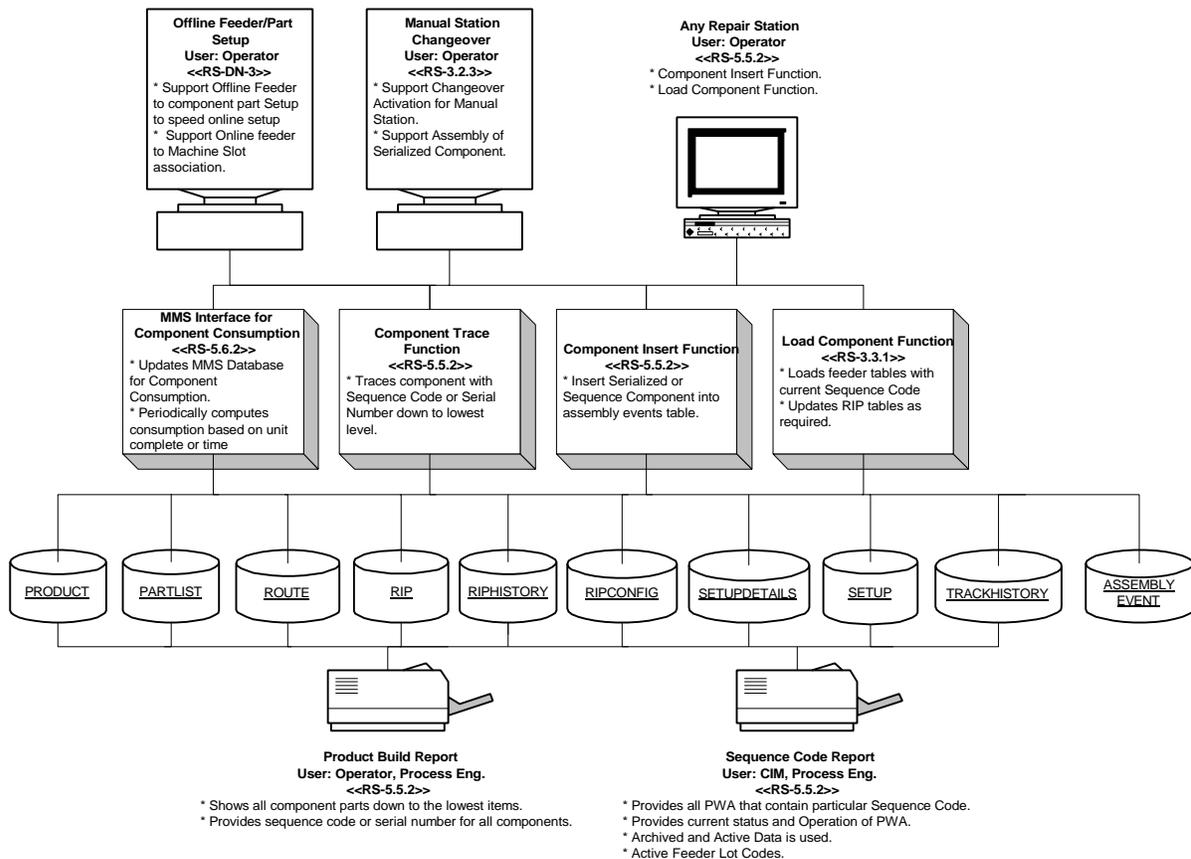


Figure 3-11.

3.11 Alarm Management (AM) Design Description

The main function of the Alarm Management (AM) Sub-System is to provide the capability to initiate, track and log events for all notable operator and application events. In this regard, AM supports the configuration, collection and reporting of all events, alarms and mail messages in the system. To achieve this a number of functional elements have to be made available. These are discussed in detail in the RS document.

The major design goals include:

- AM shall support the configuration of events, alarms, and mail entities for the Factory Control System.
- AM shall support the capability to send event notices to any station on the route.
- AM shall provide the capability to track and log all of the events, alarms or mail notifications generated by the station or Users.
- AM shall provide the capability to bring to the operator's attention notable events that have been generated by applications, or other system components.
- AM shall provide a sets of reports to provide the history of alarms for a particular product and / or user.

Figure 3-12 is the dataflow diagram which shows major design elements for this sub-system.

Alarm Management (AM) Dataflow

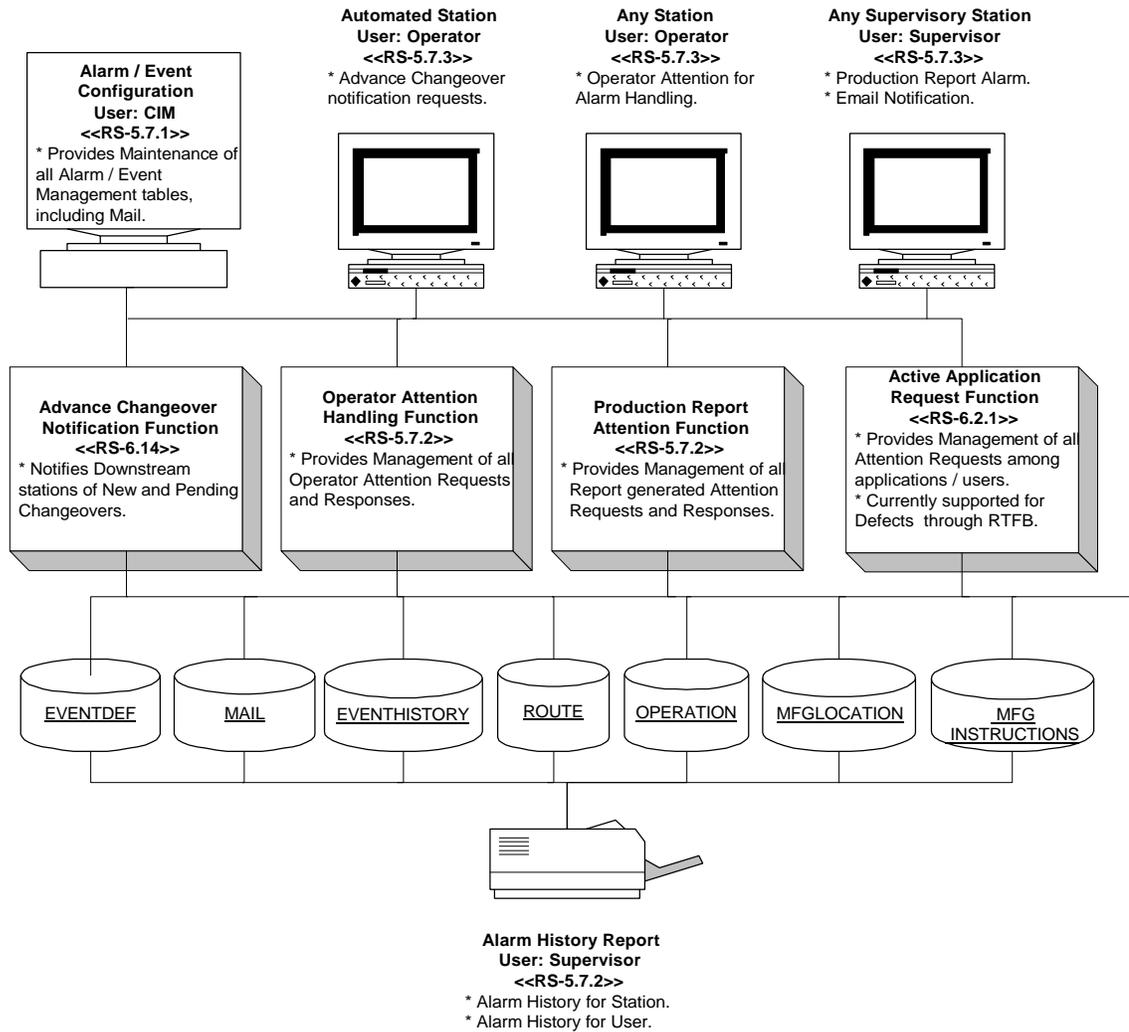


Figure 3-12.

Appendix 4 - User Based Dataflow with Description

4. User Based Dataflow with Description

The major User Based Dataflows are separated into ten sets of user interactions with the CIM System. Whereas the sub-system based dataflows provided details of all the modules, these dataflows provide the flow and modules to be used by the “user” to achieve the specific functionality desired of the CIM System.

The following major user data flows are discussed in the following sub-sections:

- Factory System Set Up
- Product Data Set Up
- Schedule a Product
- Create/Birth of the Product
- Start Product Down the Line

- Product Changeover on Line
- Component Trace based on Product/Serial Number
- Component Trace based on Sequence Code
- End Item/Component Consumption Feedback
- Archiving/De-Archiving

4.1 Factory System Setup

Figure 4-1 provides the necessary steps and the sequences that a typical “user” as defined in each of the modules will take to configure the factory system. This is the first activity to be done before any product or production activity is started.

4.2 Product Data Setup

Figure 4-2 provides the necessary steps and the sequences that a typical “user” as defined in each of the modules will take to get product data from the external Product Data Management (PDM) and Material Movement System (MMS) and work with the CIM System. This will achieve the goal of getting design and planning data to the CIM System for the necessary manufacturing bill of materials (MBOM) and machine programs.

Factory System Set Up (System Architecture - Factory Control System)

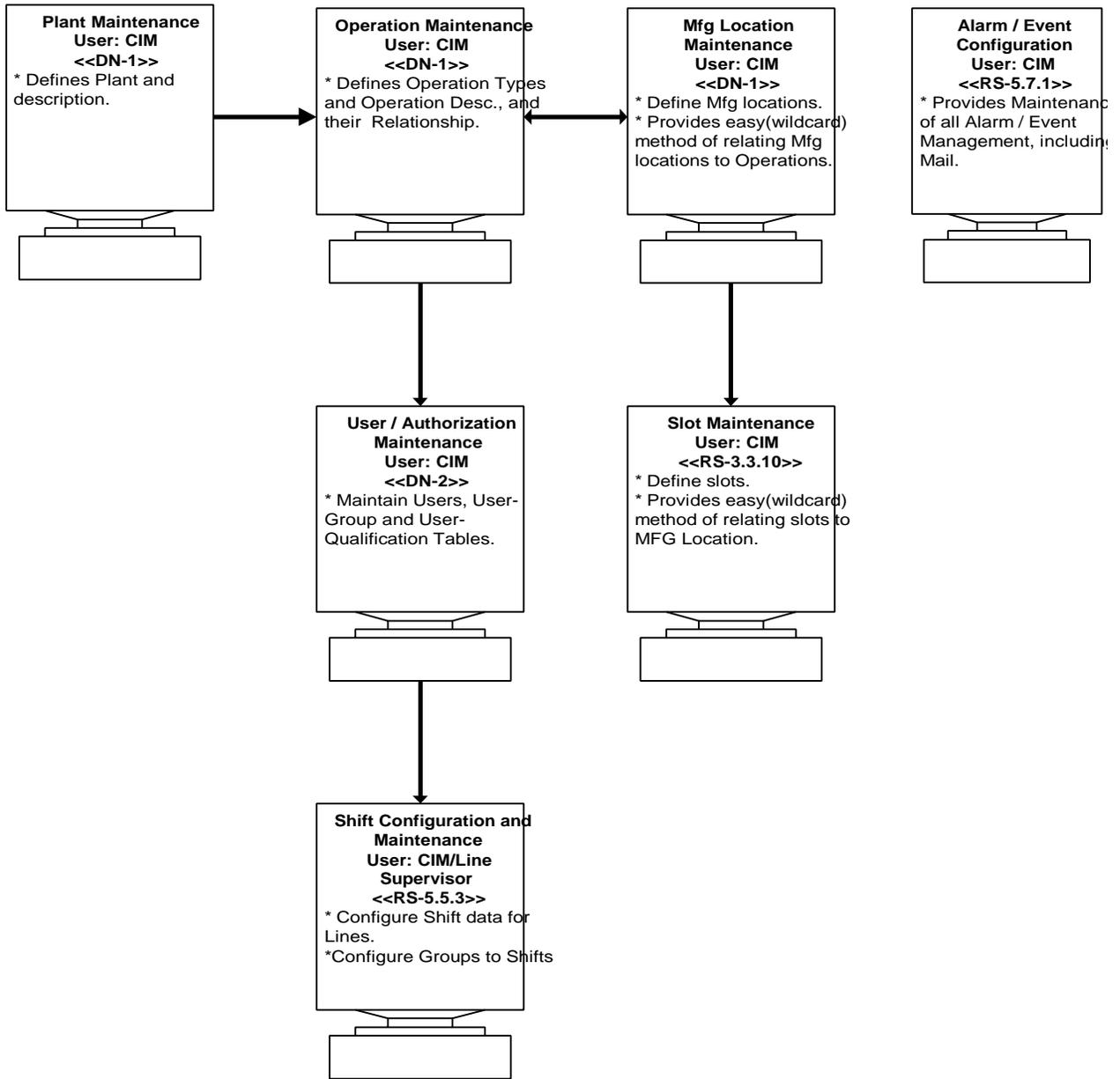


Figure 4-1.

Product Data Set Up

a). Product Data Preparation (Design-to-Production I/F System - Machine Programming System, CIM Preparation System)

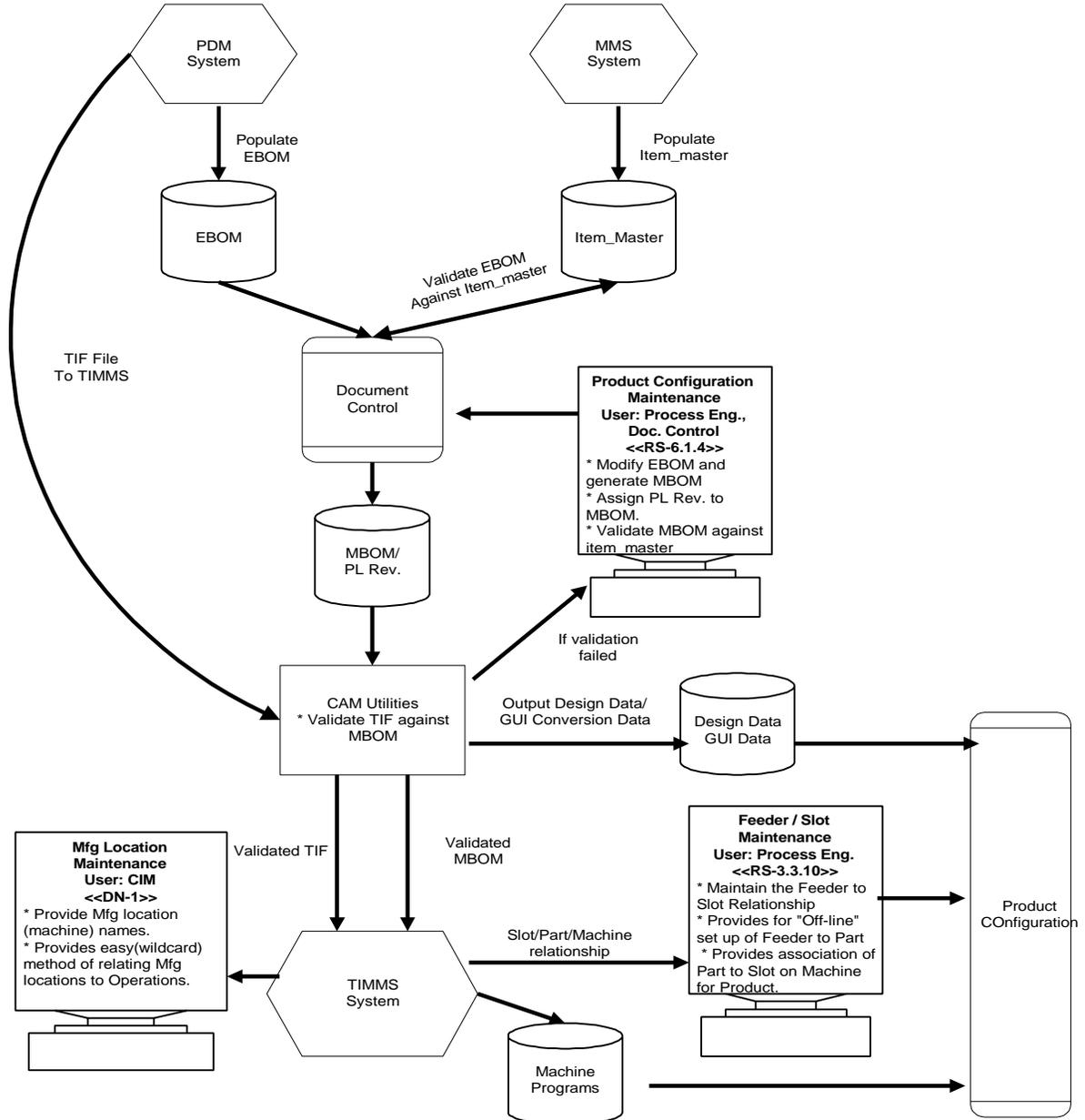


Figure 4-2.

In addition Figure 4-3, the second data flow in this set, provides the necessary supporting route and product setup data necessary to build the product on the production line.

b) Product Configuration (Production Change Over System - CIM database change over system, Operator change over system)

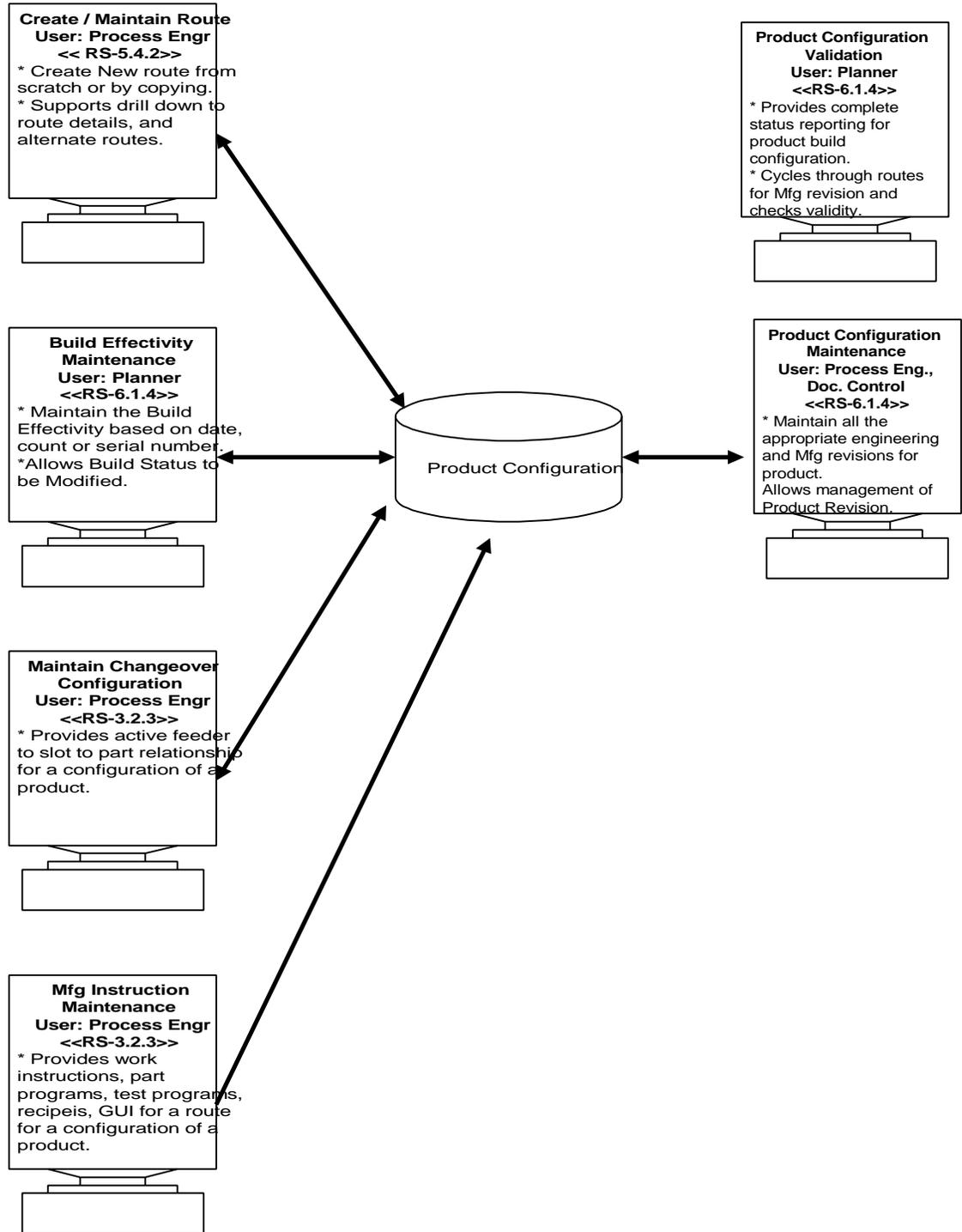


Figure 4-3.

Figure 4-4, the third user data flow in this set, provides the necessary supporting route and data set up for the quality model of the product.

c) Quality Model (Feedback to design)

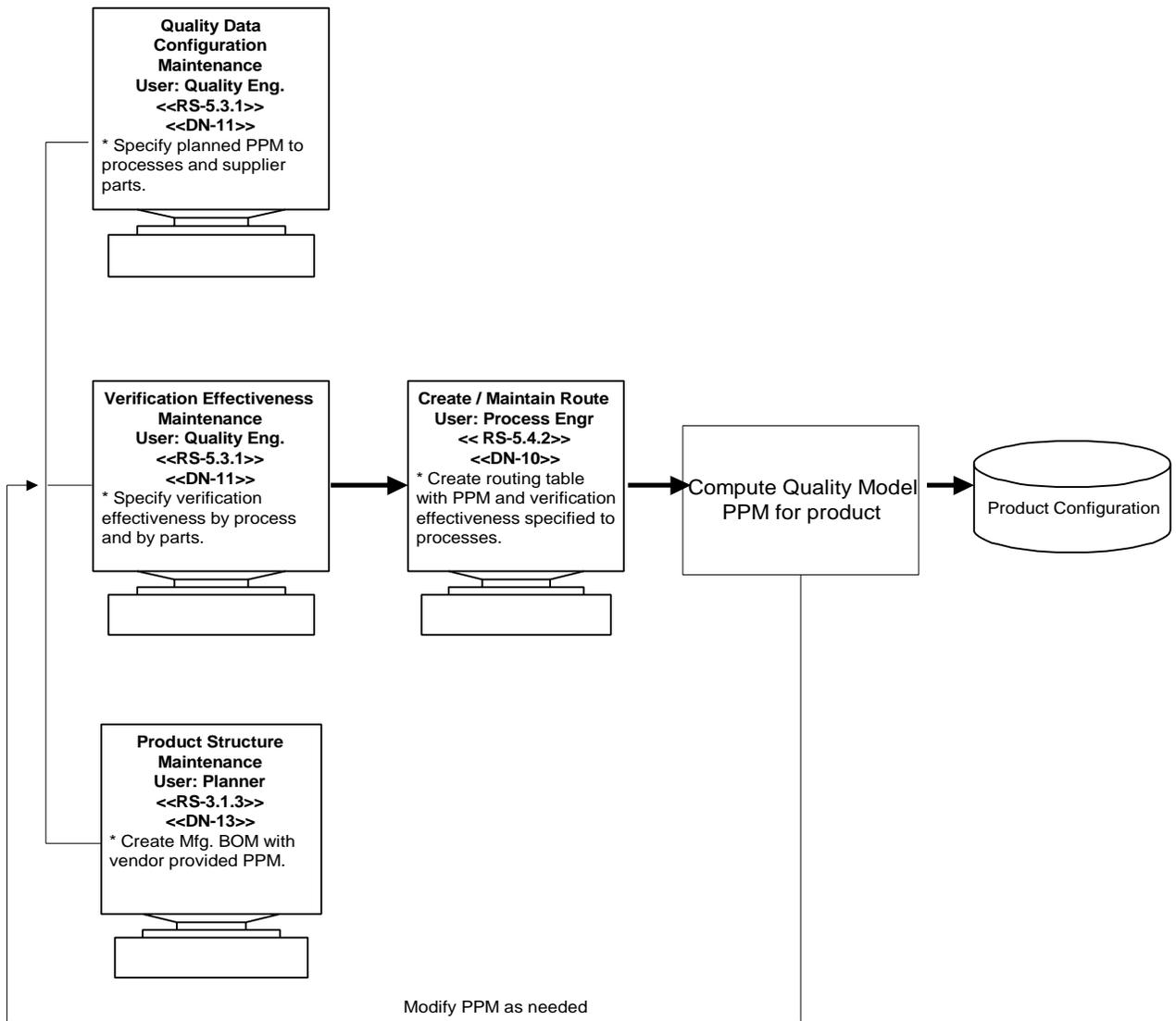


Figure 4-4.

4.3 Schedule a Product

Figure 4-5 shown below provides the necessary steps and the sequences that the planner would need to take to schedule the product for production.

Schedule A Product (Design-to-Production I/F System - CIM Preparation System)

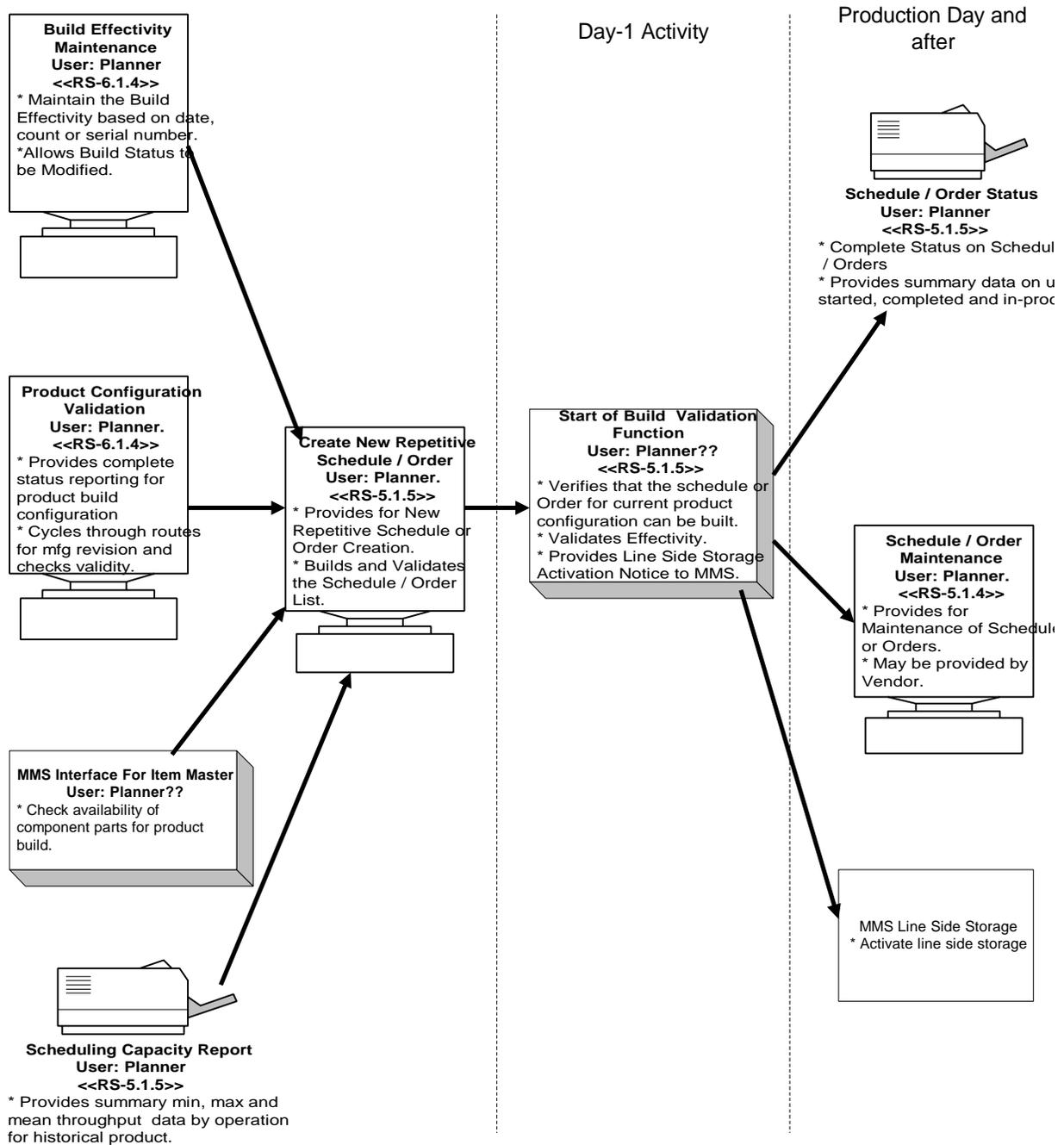


Figure 4-5.

4.4 Create/Birth of the Product

Figure 4-6 shown below provides the steps taken at the bar code label station of the line where the bar code labels are printed and applied to the PWA for the requested schedule. The numbers on the arrows show the sequence the controlling Work Station will take to achieve this purpose.

**Create/Birth Of The Product (Design-to-
Production I/F System - CIM Preparation System)**

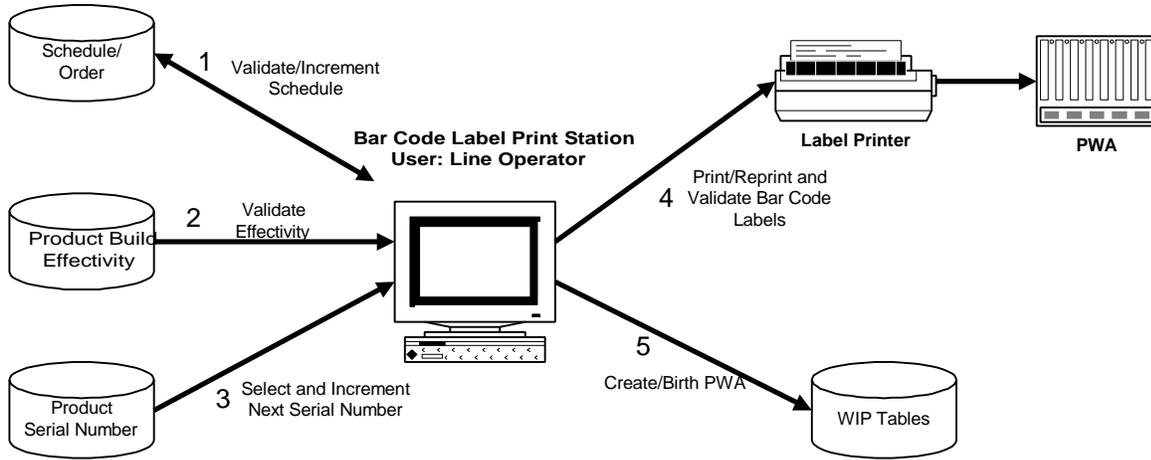


Figure 4-6.

4.5 Start Production Down the Line

This dataflow shown below in Figure 4-7 provides the steps taken at the first production station of the line where the PWA label is scanned and appropriate validation is done to start the PWA down the manufacturing line.

Start Product Down The Line (System Architecture - Work Cell Controller System)

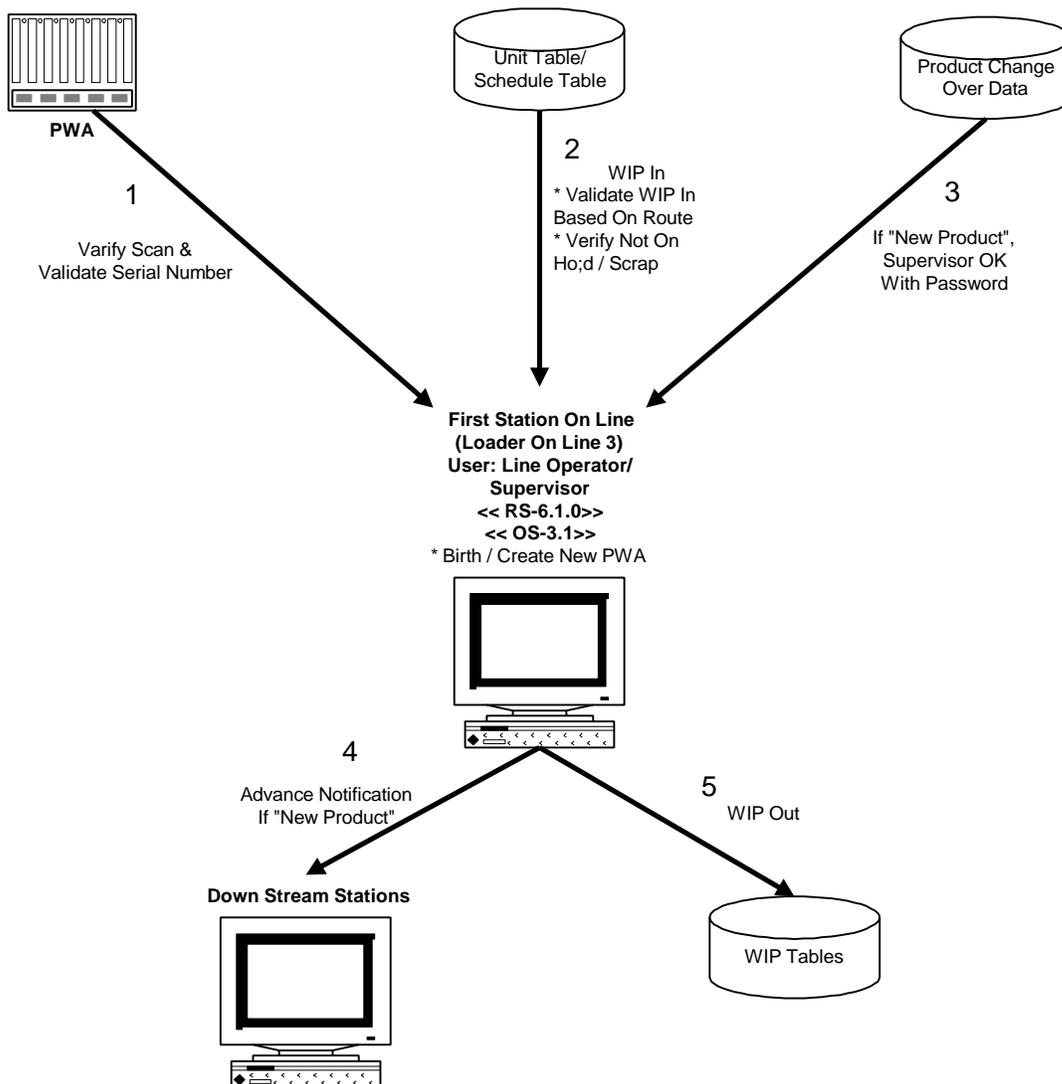
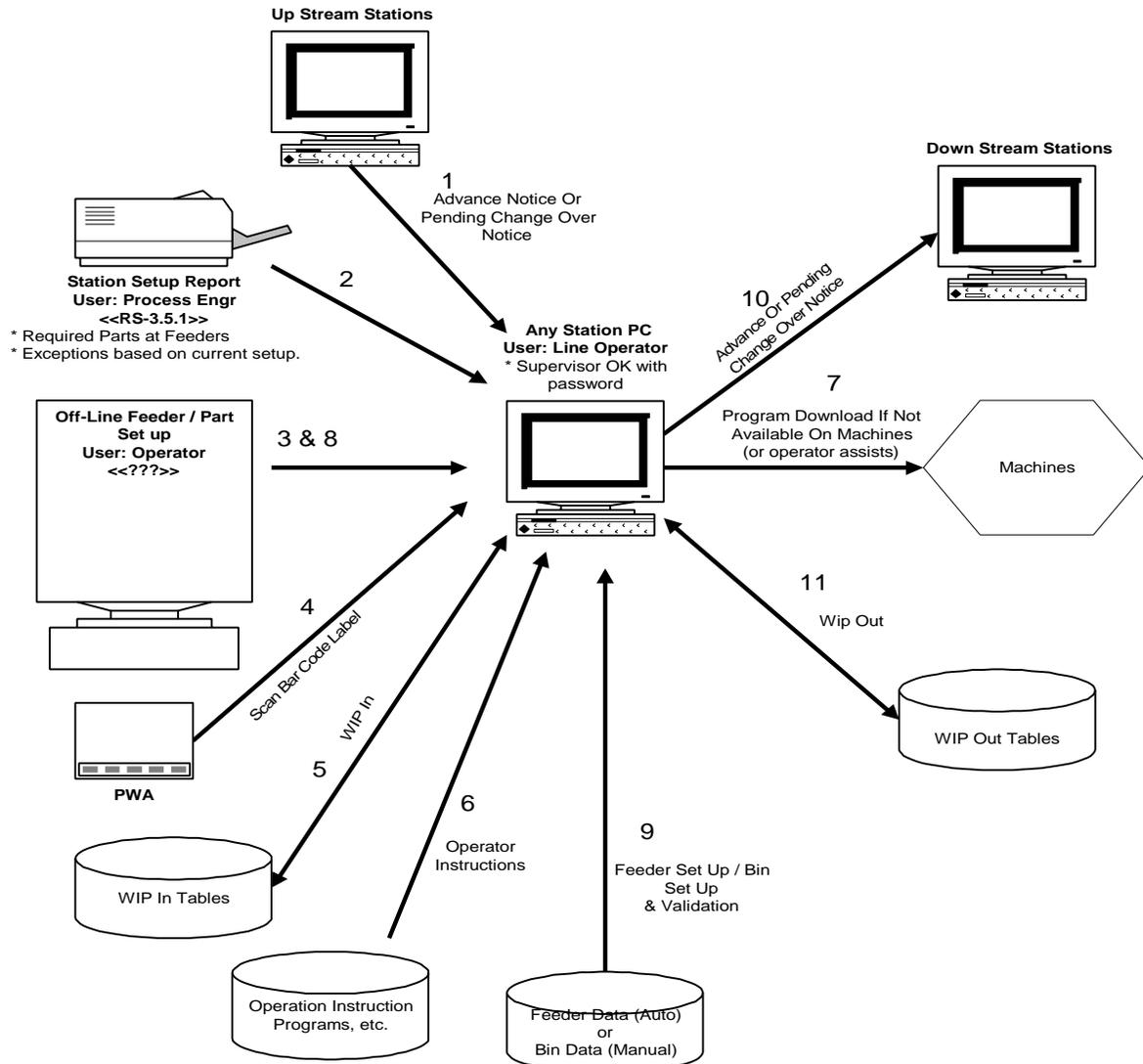


Figure 4-7.

4.6 Product Changeover on the Line

This dataflow shown below in Figure 4-8 provides the steps taken at the second and subsequent station of the line where there is need for production set up changes to build a different product than the one being built currently. The numbers on the arrows show the sequence order the controlling Work Station will take. The dataflow shows two separate sequences - one for changeover preparation when an “advance” notice is received and the second for the changeover.

Product Change Over On Line (Production Change Over System, System Architecture - Machine/Line I/F System)



Note: 1, 2, and 3 are advance notification for product change over

Figure 4-8.

4.7 Component Trace based on Product/Serial Number

This dataflow shown below in Figure 4-9 provides the steps taken by the “users” shown below to identify the necessary reports available for each and every PWA built in current and planned CIM System..

Component Trace Based On Product/Serial Number (Production Performance and History System - IBP Traceability System, IBP Product Specific Needs)

Users: Quality, Manufacturing, CIM Engineers

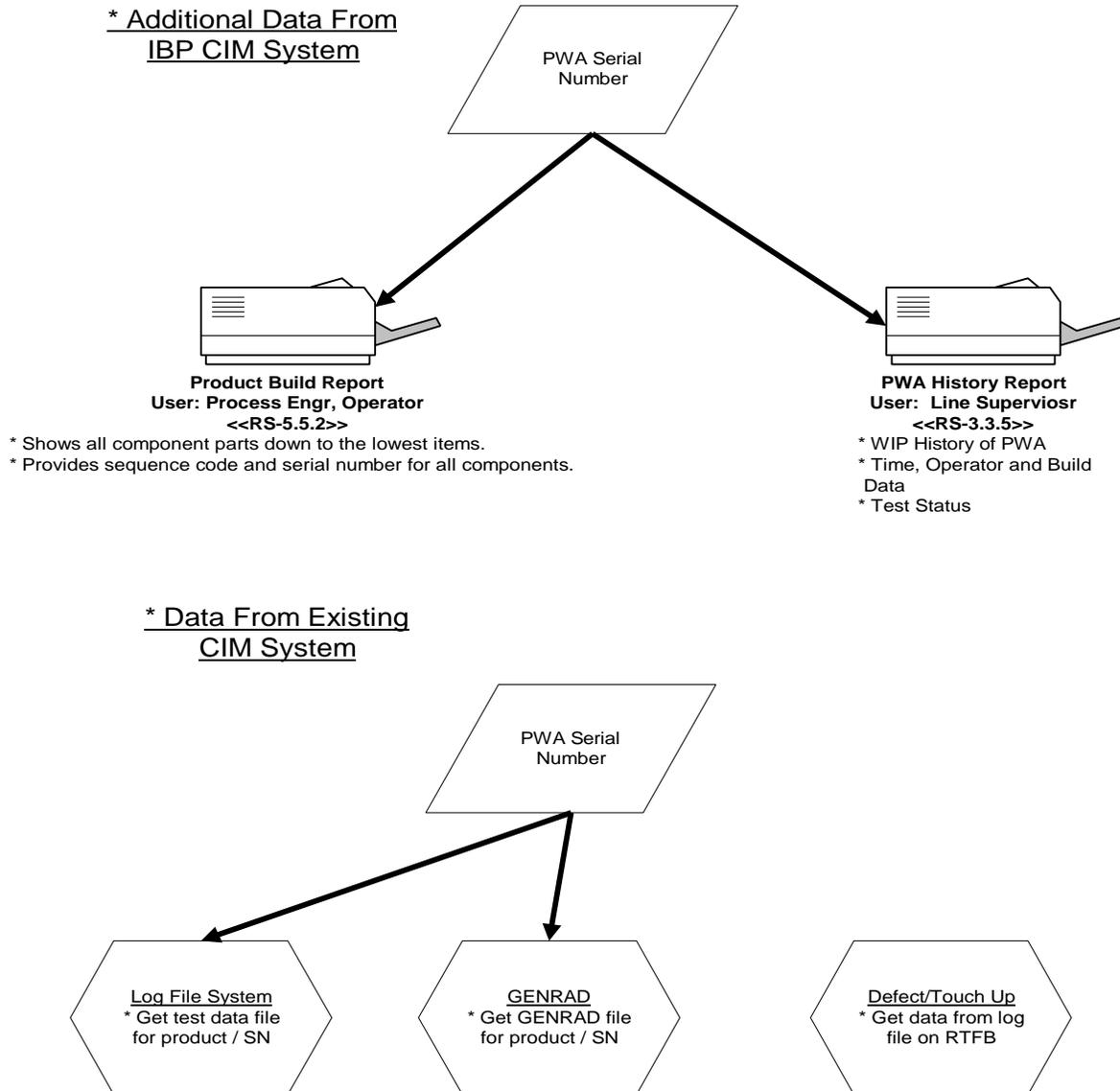


Figure 4-9.

4.8 Component Trace based on Sequence Code

Figure 4-10 below shows the steps taken by the “users” shown below to identify the necessary reports available for each and every Sequence Code that may be a cause for concern in the system. Note the capability to also purge the active components and PWA from the production line.

Component Trace Based On Sequence Code (Production Performance and History System - IBP Traceability System, IBP Product Specific Needs)

User: Quality, Manufacturing, CIM Engineers

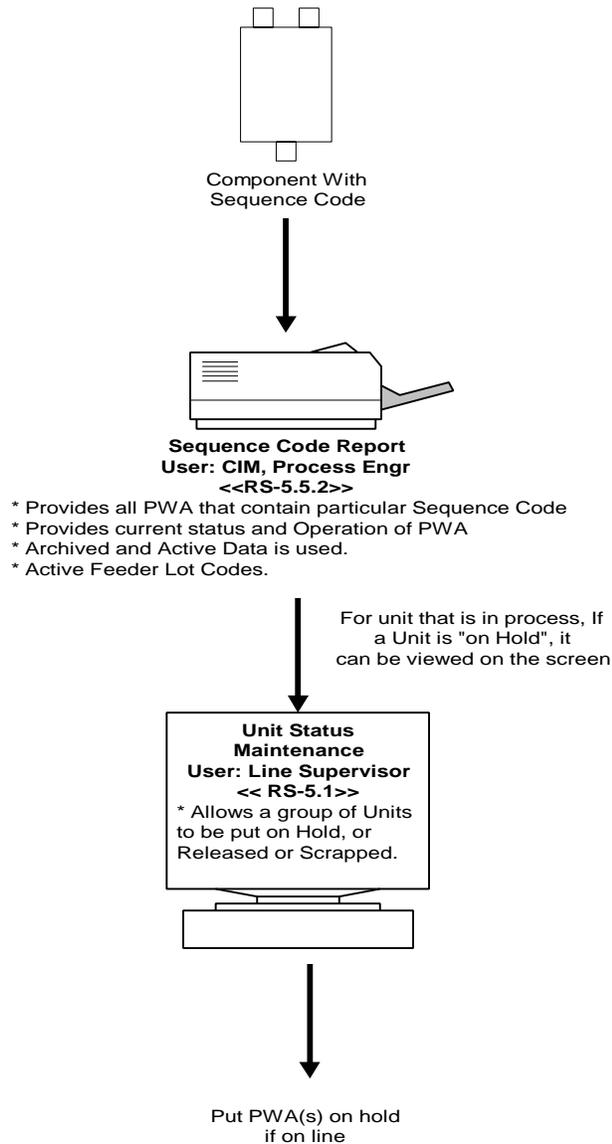


Figure 4-10.

4.9 End Item/Component Consumption Feedback

Figure 4-11 shows the steps taken by the “users” and the system to identify and report the component consumption and the end item PWA inventory. This capability is to be provided on a timely basis, and depending on the performance of the system may be “real-time”.

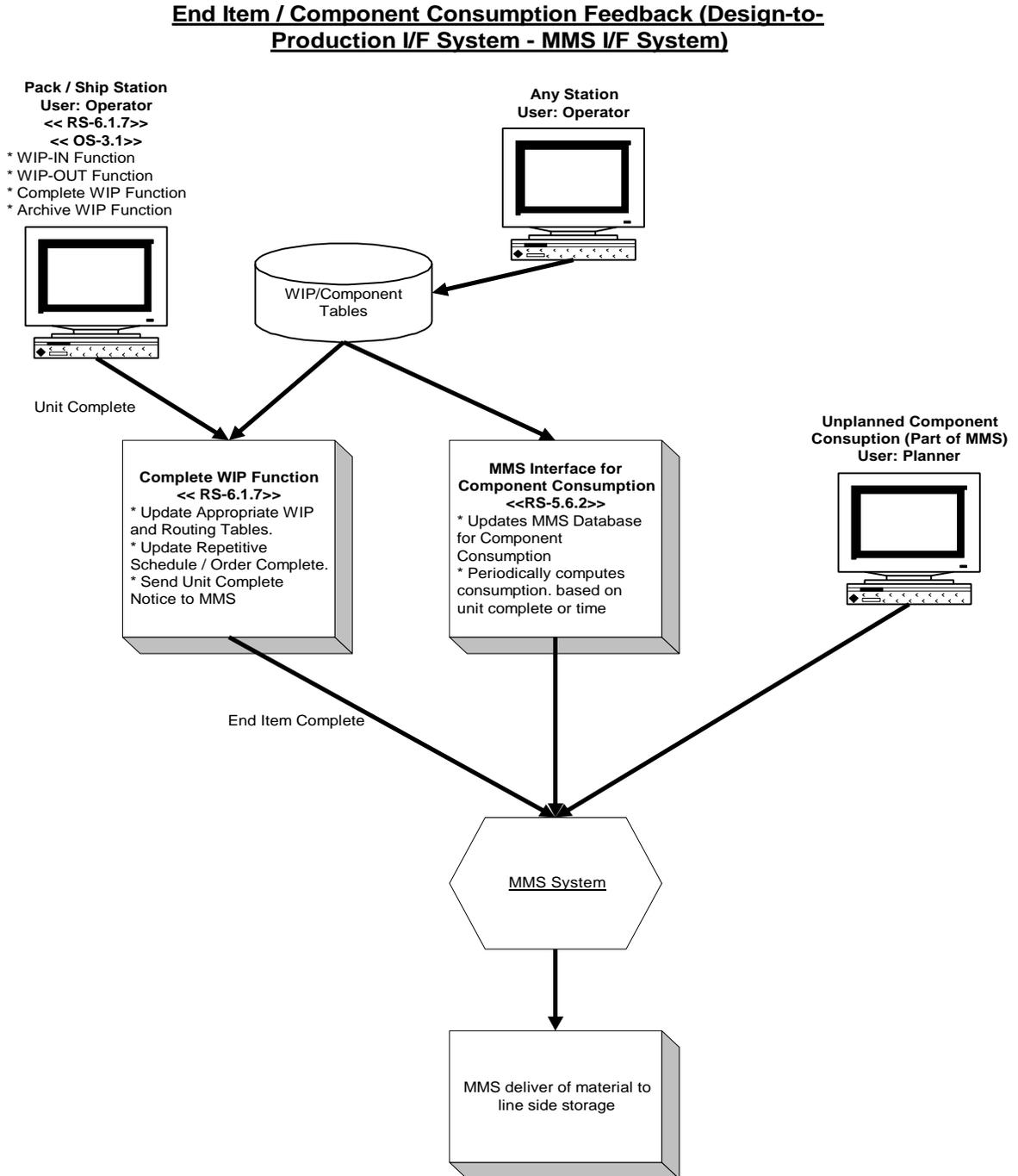


Figure 4-11.

4.10 Archiving / De-Archiving

This dataflow shown below in Figure 4-12 provides the steps taken by the database administrator and the system to provide archiving and supporting de-archiving capability.

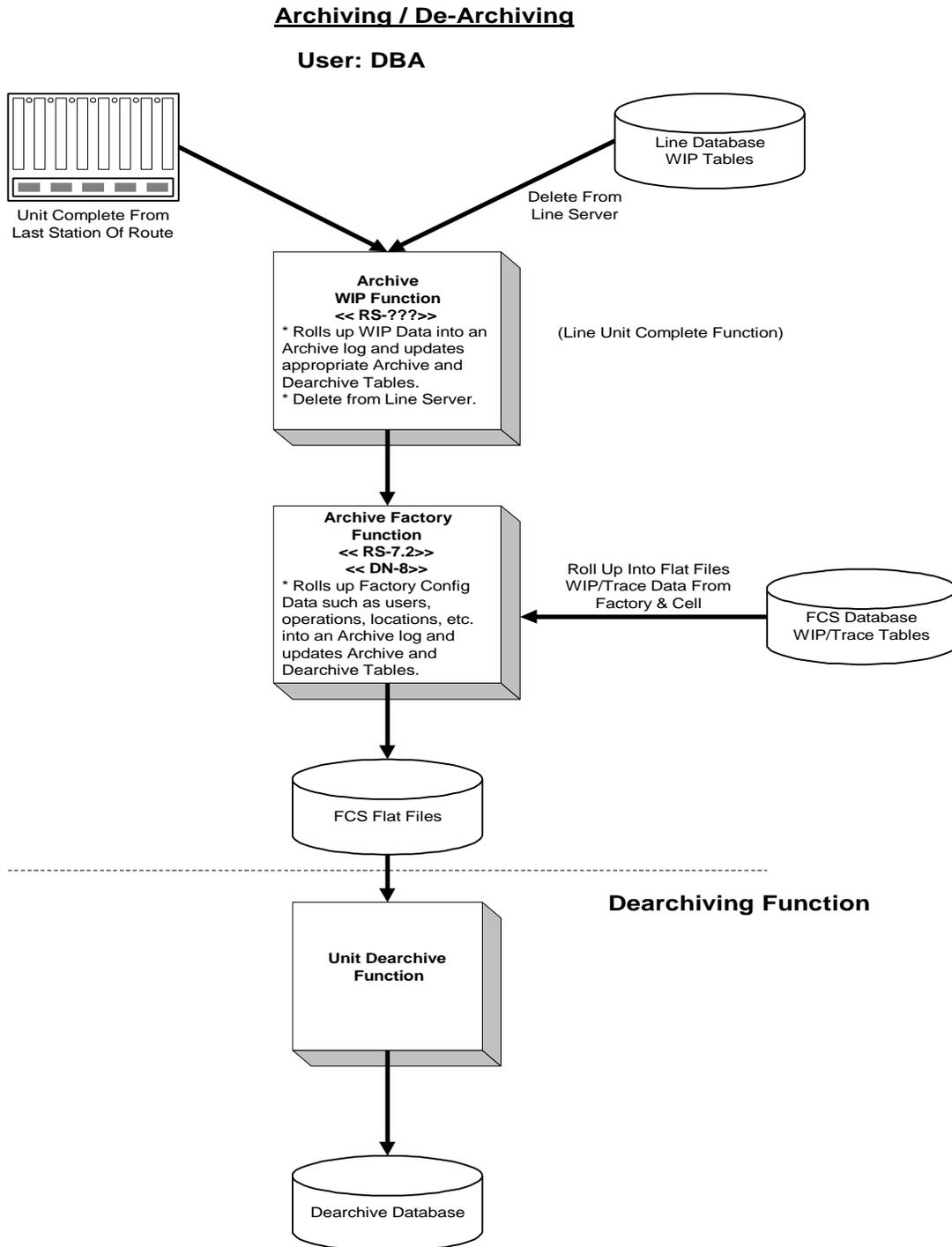
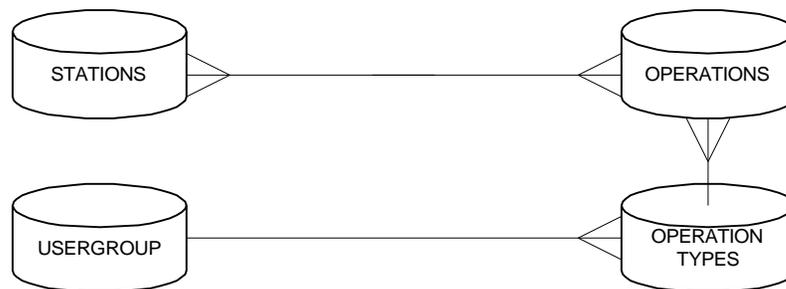


Figure 4-12.

Appendix 5 - Design Notes (DN)

- Each of the physical locations where work is to be performed is considered a “station” or Mfg. Location. Where ever a PWA is inspected, tested, added to or changed, that functional entity is an “operation”. Typically a station performs one operation. For reasons of production there may be many “stations” that perform the same “operation”. Conversely, for activities that are sporadic, or do not require a significance amount of work, there may be many “operations” performed at a single “station”. In addition, Operation Type is used to provide some level of authorization. The same class of operation belongs to the same Operation Type. Typically a user or user group is defined to be capable of performing an Operation Type. The relationship among them is graphically represented as follows:

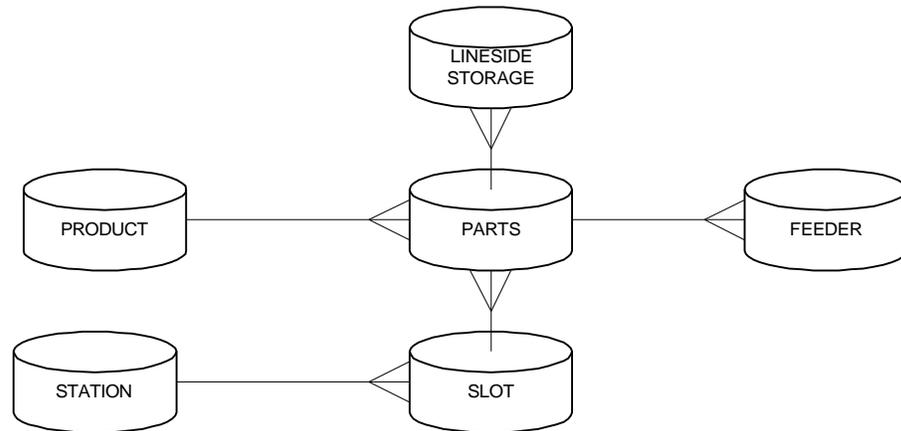


- To support the capability and flexibility of having user authorization and shift data collected, the design of the data model will relate users to user groups. The system is capable of providing a generic user belonging to a generic group, all of who can do every operation type, and belong a single shift. This is the simplest way to minimize user protection. On the “secure” end, all users can have their own passwords and be capable of performing only certain operation types on a certain shift. This relationship is show below:



- The relationship between the various storage devices and machine locations is given in the diagram below. For standardization, the following is to be the terminology to be used.
 - Slot (aliases are Bin, Box) -- is the physical location on a station (Mfg. Location) where parts are inserted. In the case of reeled parts, reels are placed on the feeder and the feeder assembly is placed in the slot.
 - Feeder -- is the physical device on which reeled parts are placed. Feeder may have his or her own identification. They are not related to any particular machine.

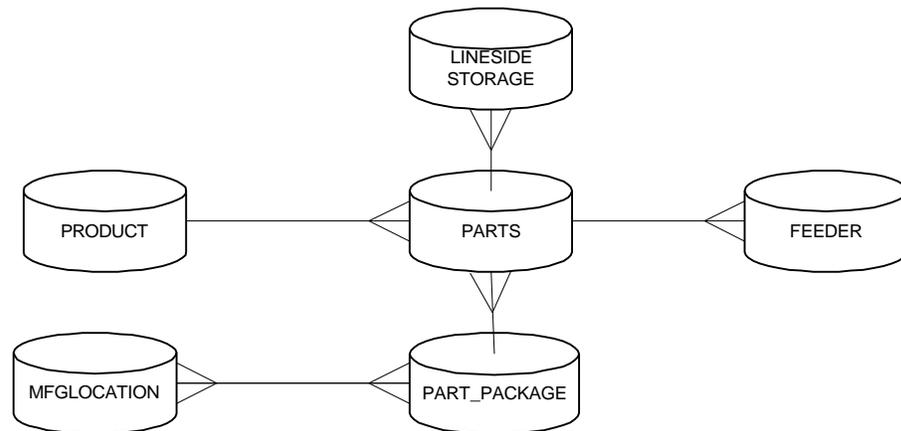
- Line Side Storage --are the locations on the plant floor next to production lines where temporary storage is made of parts of short-term consumption.
- Part -- is the component part that is related to a slot on a particular machine for a specific product. It may temporarily be put on a feeder assembly.



In support of this design, the off-line feeder part setup shall be provided so that Feeders may be setup “off-line” with feeder to component part/sequence code data. Then when the feeder is used for replenishment or changeover, the operator will only need to associate feeder to machine slot. This will result in the system than identifying slot to component part for Product, with the associated sequence code.

4. The Repetitive Schedule is defined by the planner and is capable of providing build request of quantities for shifts, days, or weeks. Each of the build requests shall have a reference build number consistent with the way an order is generated and built. The Start of Build Validation is to provide for daily validation of orders or of the repetitive schedule. If the order/schedule is “old”, then only MMS line side storage activation shall be done else validation and activation is to be done.
5. The MMS Interface is to support the activation of which line side storage locations are to be monitored. The capability to be provided by the CIM System is what bins are to be activated based on the product being built.
6. The Planned Setup Report is provided for the supervisors or operators to look at the setup for each and every station on the line for a particular product. This data is originally provided by the TIMMS/2 system, and utilities are provided to put this data into the CIM System database for reporting purposes.
7. The master control of the next valid serial number is to be maintained in the CIM database. For maintainability of this data, supervisory control should be made available and the necessary forms provided.
8. Archiving and Dearchiving of data is critical to a system where the production volume is high. To this end the strategy for the archiving and dearchiving is a follows:

- Deletion -- All WIP data from the Line servers shall be deleted when the unit is “completed”. Data is to remain in the FCS DB until it is archived. Also all product, component trace, and event data is to be deleted from the Line Server “periodically”. This will be done by the Database Administrator (DBA). When any significant changes are made to the production line, the entire database for the line server is to be deleted and only the relevant tables for the new products populated by the DBA.
 - Archiving -- All WIP and Trace data from the FCS server shall be rolled up into flat files and compressed. This activity is to be done when the unit has been “completed” for over 1 year. In addition, all table data that is over a year old is to be archived using Oracle tools then deleted from the tables. This activity is to be done on a monthly basis with a rolling 1-year window. This will be done by the Database Administrator (DBA).
 - Dearchiving -- Depending on the need for dearchiving either the archived tables or the flat file WIP and Trace data is brought back into “new” tables. Tools and utilities for the normal table dearchiving will be provided by the Oracle RDBMS. For flat files, PL/SQL and SQL*Forms utilities will be provided to allow this data to be quickly scanned for items such as “sequence code for components”, start or complete dates, etc.
9. In support of the Quality Model integration with the CIM System’s bill of material and configuration management applications, clarifications are as follows:
- All the component parts in the product must have their part packages defined. For sake of simplicity, only the high PPM component parts should be defined. As the product gets closer to Production, all other parts can be added.
 - For each component part/package type, the MFGLOCATION that the part and the associated slot it will be used in. For sake of simplicity, the slot does not have to be exact. They can be off until the actual part programs are done. Also the MFGLOCATION can be some default “Machine” if so desired. The selection of the actual machine can be done after the part program is generated.
 - The relationship between the various storage devices and machine locations is given in the diagram below. For standardization, the following is to be the terminology to be used.
 - Part-package -- is the package type that can be place by a station (Mfg. Location) where parts are inserted. There is a many to many relationship between MFG_LOCATION and PART_PACKAGE.



10. User will then define the route the product will follow as it is being produced on the manufacturing line. This will entail defining for the CIM system the following:
- All the OPERATIONS and /or MFGLOCATION's. For sake of simplicity, only the high Process PPM drivers and Verification processes should be defined. As the product gets closer to Production, all other locations can be added.
11. To support the capability and flexibility of having generalized to very specific PPM levels for the product, the following order of precedence for "PLANNED" or "ACTUAL" PPM levels each station, operation or operation type on the route will be followed:
- If MFGLOCATION is specified, the planned or actual PPM will be used based on the part_package type., if no PPM is available, then it will go the to next higher generalized level of "operation"
 - If OPERATION is specified or no PPMs are available from MFGLOCATION, planned or actual Operation PPMs are to be used. Note that this is independent of part_package type. however if not available then it will go the to next higher generalized level of "operation type"
 - If OPERATION PPMs are not available OPERATION TYPE planned or actual PPMs are to be used, however if not available an error will be generated for the model.
12. The current CIM Data Model uses a simple Yield concept. To support the Quality model the PPM concept is being added and it shall be made comprehensive to support the following:
- Every Physical or logical entity in the plant that affects the quality of the product will have a PPM ID. For the basis of the Quality Model there will be three (3) types of PPMs. Process PPM, Part PPM and Verification Effectiveness PPM. The data model will allow further expansion to include Design PPMs, etc.
 - Process PPMs are for process locations such as MFGLOCATION, OPERATION, OPERATION_TYPE. This PPM ID will point to two PPM values - one "planned" and the other "actual". "Planned" values are to be entered by the Quality or Planning personnel. "Actual" will need to be computed on a periodic basis from feedback from the Real-Time Defects Databases and entered by the Process personnel.

- Component PPMs are for component parts and products. Similar to process PPM, the PPM ID will point to two PPM values - one “planned” and the other “actual”. “Planned” values are to be entered by the Quality or Planning personnel based on some planning value “Actual” will that which is provided by the part vendor and entered by the Process personnel. In addition, if neither is available the values for the PART_PACKAGE will be used. This will point to the same PPM Type.
 - Verification Effectiveness PPMs are for all quality assurance locations such as In-Circuit Test, Visual Inspection, etc. This PPM ID will point to two PPM effectiveness values - one “process” and the other “component”. “Process” values are how effective the location is in performing the verification on the process defects. “Component” values are how effective the location is at performing the verification on the component flaws. Note that this verification is to be comprehensive and shall take into account that this verification effectiveness may be applicable to only a subset of components and processes. Supporting Data Structures shall be needed to support user interaction to specify this and keep in the database for future use and traceability.
13. Finally the User can interact with the QM and get output in the form of a screen report that will look like spreadsheet report. Note the following:
- The user will “adjust” PPM levels by identifying new PPM Values or changing existing values and seeing the impact to the bottom line PPM.
 - The user may alternatively modify the route; the bill of material associated to the route and re-run the model parameters to get a new value.
 - Note that the order of Operations in this model is important, as the model is sensitive to what order of the operations.
 - A spreadsheet like view will need to be provided to the user to ascertain which processes and parts are being “verified” by the processes that have verification effectiveness. The level of effective is the same for all type is “checked”, and zero if “not checked”.