GENERAL DYNAMICS
FORT WORTH DIVISION

INDUSTRIAL TECHNOLOGY MODERNIZATION PROGRAM

Phase 2
Final Project Report

PROJECT 51/52

MODERNIZING TECHNIQUES AND QUALITY ASSURANCE SYSTEMS

REVISION 2

Honeywell
Military Avionics Division

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This project is directed toward dedicating and pacing electromechanical assembly lines by reducing the various products into four major groups, by integrating the subassembly operations into the flow, designing assembly lines with flexibility, and automation and efficient system configuration to allow for quick changeovers. The individual work stations, which are part of the assembly lines, will be modular and flexible and will allow for changes and adjustments triggered by volume and product changes. The work stations will be ergonomically designed to best meet the operator's needs. Travel and handling distances for material and the physical part moves will be optimized and automated to increase operator productivity as part of the assembly process. Subassembly operations will be performed on-line (as part of the line, not partially off-line) to best cycle and pace the lines and keep inventory at a low level. Operators will be dedicated to a line, yet cross-trained in several processes to optimize their utilization and minimize the dependency on operators with specialized know-how. This project focuses on the development of an advanced quality

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assurance system for deleting "verification only" inspection operations and emphasizing "value added" inspection contributions to the production process. This will be accomplished through the implementation of semi- and fully automated in-process inspection and statistical quality assurance techniques. The goal is to reduce scrap and rework, minimize parts handling ~~and staging~~, and improve the quality level.

Keywords: Industrial production

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FORT WORTH DIVISION

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REVISION 2

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PROJECT 51/52

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PROJECT 51/52

MODERNIZING TECHNIQUES AND QUALITY ASSURANCE SYSTEMS

SECTION 1

INTRODUCTION

The Precision Control Instruments (PCI) business area is located in Honeywell's Stinson/Ridgway facility. PCI is part of the Inertial Instruments Operations (IIO) within the Military Avionics Division. This area designs and produces precision navigational components and systems. Production primarily performs delicate assembly operations under clean room conditions for both commercial and defense markets.

Project 51/52 will address the major product areas of PCI which include:

GG1111 Rate Gyroscope

The GG1111 is a Subminiature Rate Integrating Gyroscope with state-of-the-art features. It consists of a synchronous-hysteresis motor with high reliability, a moving-coil signal generator that provides a linear electrical output signal proportional to the angular displacement of the gimbal, a moving-coil, and a permanent-magnet torque generator with extremely high torquing capability, excellent linearity, and minimum temperature sensitivity. It also has a stable and inert silicone fluid for flotation and damping, precision radial ball bearings that maintain gimbal alignment and proper axial positioning of the gimbal within the gyro case. The GG1111 gyro is readily adaptable to various power supply interface requirements and performance requirements. The size of the GG1111 is approximately 1.3 inches in diameter and 2.5 inches in length.

GG4400/GNAT Rate Gyroscope

The GG4400 gyro, a low cost successor of the Gnat, is a high performance sensor for control system damping, rate stabilization, and instrumentation. The GG4400 gyro contains a synchronous hysteresis motor sealed in an inert atmosphere. The gimbal, supported between an isoelastic low hysteresis spring and a miniature low friction pivot/bearing assembly, operates as a single-degree-of-freedom instrument. A variable reluctance signal generator produces an output signal proportionate to input rate. The damping gap is controlled to allow minimal variation of the damping ratio over a wide temperature range. Silicone oil, used as the damping fluid, provides extra protection against shock and vibration. The stainless steel housing uses all welded seals to provide a positive hermetic seal. The GG4400 is currently employed in torpedo, aircraft, missile and tank turret stabilization and control systems applications. The size of the GG4400 is approximately 1.0 inches in diameter and 2.25 inches in length.

Accelerometer Packages

The accelerometer packages supply acceleration and rate of turn data to the guidance system and or display system of the vehicle. These packages consist of two or three rate gyros and zero to three accelerometers, a mounting casting, for holding sensors and electronics and a cover for protection from physical damage and moisture. The sensors are mounted orthogonally in the roll, pitch and yaw attitudes. The package normally includes electronics to power the sensors and amplify the sensor outputs to the level desired by the user. Sensor outputs are typically used to control airframe surface elements or used in conjunction with radar for pilot target data.

Current packages vary in size from 42 cubic inches (Tomahawk: 3.5" x 4.7" x 2.7") to 171 cubic inches (F-16: 6.5" x 5.0" x 5.25").

Project 51/52 is directed toward dedicating and pacing assembly lines by:

- Reducing the various product groups into major groups.
- Integrating the subassembly operations into the parts flow.
- Designing the assembly lines with flexibility.
- Automating to allow for quick changeovers.
- Focussing on an advanced quality assurance system that will be directed at deleting "verification only" inspection operations.
- Emphasizing "value-added" inspection contributions to the production process.

Individual work stations will be part of the assembly lines. The work stations will be modular, flexible, and will allow for changes or adjustments triggered by volume and product changes. The work stations will be designed ergonomically to best meet the operator's needs. Travel and handling distances for material and physical part moves will be optimized and automated to increase operator productivity. Operations, as part of the assembly process, will be performed on-line (as part of the line, not partially off line) to best cycle and pace the lines. Consequently, work-in-process inventory will be pushed to its lowest level. Operators will be dedicated to a line; however, they also will be cross-trained in the processes as much as possible to optimize operator utilization and minimize the dependency on operators with specialized know-how. Automated or semi-automated equipment will be used to emphasize "value added" production and inspection operations. This will relieve operators from strenuous and repetitive operations and will improve the likelihood of keeping the assembly lines paced.

Improvements will occur in Quality data-gathering and dissemination utilizing computers and statistical quality assurance techniques. Also, the effectiveness of the support services will be increased by establishing mixed line teams of support personnel which are exclusively dedicated and responsible to only one assigned assembly line and are co-located with that assembly line.

NOTE: Honeywell's IIO Tech Mod program management had requested and received Air Force and General Dynamics approval for the combination of Project 51 (Increase Productivity and Reduce Lead Time Through Modern Techniques and Advanced Technology) and Project 52 (Advanced Quality Assurance System For Inertial Components Systems). This was recommended due to the complexity in separation and documentation of similar cost drivers within both projects.

SECTION 2

PROJECT PURPOSE/OVERVIEW

The Project 51/52 objective is to modernize and improve the production and quality verification of precision navigational components and systems in the Precision Control Instruments (PCI) business area of the Inertial Instruments Operations (IIO). Strong emphasis is placed on reducing product costs, shop and system lead times, and at the same time improving the quality and reliability of those products.

The general objectives were:

- Reduce product costs of the Precision Control Instruments products by splitting the present product groups into four related families with common process similarities.
- Apply the most effective advanced technologies to the production processes.
- Minimize material moving, handling, and staging for quality assurance operations.
- Utilize Just-In-Time (J.I.T.) concepts to reduce work-in-process inventory.
- Reduce manufacturing lead times due to inspection delays.
- Provide flexible assembly lines to allow for quick changeover.
- Move focus of quality assurance from product verification to statistical process control.
- Develop methods for establishing production process control limits on significant mechanical and electrical characteristics for subassemblies and end items.
- Improve the quality level of PCI products with the goal of zero defects.
- Apply the Computer Integrated Manufacturing (CIM) system concept and work toward the paperless factory.
- Improve the capabilities of the final test utilizing state of the art Automatic Test Equipment.
- Develop methodology to incorporate real traceability in conjunction with configuration management.
- Dedicate and co-locate production teams and support personnel to provide product focus.
- Provide surge capacity.

SECTION 3

TECHNICAL APPROACH

The technical approach for Project 51/52 was as follows:

1. Established program baseline consisting of product groups, product similarities, processes and operations, redundant operations, test and quality assurance requirements, bottlenecks, schedules, tools, fixture and equipment requirements, clean room and space requirements, and costs.

2. Developed modernized and improved manufacturing system (based on dedicated and paced line concept), processes, data analysis and quality criteria, techniques, methods, product design needs, procedures, floor layouts training, material handling systems, and facility needs.

3. Developed alternative manufacturing systems, layouts, in-line inspection stations with dedicated equipment and mobile inspectors, processes, information systems, material handling systems, controls, technologies, methods and procedures, and use of computer simulation and modelling techniques to optimize solutions.

4. Selected the optimal alternative of the developed modernization and improvement solutions which best met departmental and program objectives and could be considered a long term solution for IIO.

5. Finalized floor layouts, process layouts, standards, quality, and test points. Identified software and/or costs to modify software that would enable access to discreet Production and Process Control data and confirm product acceptance without repeating previous operations.

6. Established necessary interfaces and function points with the Honeywell Manufacturing System (HMS). Developed CRT video systems for Production/Inspection Instructions, data reporting, and Quality records. Generated computer printed forms as required.

7. Finalized selected alternatives and included necessary modifications, additions, and improvements to meet project objectives and guarantee interfaces with other departments and various divisional systems or programs.

8. Developed and prepared preliminary specifications required for the modernized and improved manufacturing environment in PCI. These included specifications for facility re-arrangement and clean room upgrade, equipment, the material handling system, tools, hardware and software, locations in the production process for new measurement and data collection equipment, and statistical process control methods.

9. Reviewed the Production Process. Identified operations where Production could utilize Process Control and reduce in-line Inspection time. Reviewed and analyzed the Automatic Test Equipment capabilities. Identified improvements which included reduced in-line inspection time.

10. Submitted preliminary specifications to selected and qualified vendors for quotes.

11. Established training needs required for the modernized and improved manufacturing environment for production personnel, support services, and line management.

12. Reviewed and evaluated vendor quotes by using decision matrix techniques, risk analysis, and cost benefit analysis.

13. Selected vendors for plant equipment (clean room related, etc.), shop equipment, the material handling system, factory systems, and software. Updated selected plans and layouts.

14. Modified specifications of plant equipment, shop equipment, the material handling system, tools, systems, hardware, and software based on marketplace response to stated needs and/or vendor capabilities.

15. Developed and prepared an implementation schedule including interfaces with existing and planned divisional or departmental systems, neighboring departments, interim production, changeover, and training.

16. Prepared a final cost benefit analysis.

17. Developed a cost tracking technique which could be used in monitoring program costs and improvements.

SECTION 4

"AS-IS" PROCESS

The Precision Control Instruments (PCI) business area is located in Honeywell's Stinson/ Ridgway facility. PCI is part of Inertial Instruments Operations (IIO) within the Military Avionics Division. This area designs and produces precision navigational components and systems. Production primarily performs delicate assembly operations under clean room conditions for both commercial and defense markets. The entire PCI production area covers approximately 49,000 square feet. The "As-Is" PCI space distribution is shown in Figure 4.1.

PCI assembles and tests gyros and accelerometers for both internal and external use. It also produces a variety of electronic rate and acceleration packages, generally consisting of two or three electronic printed circuit boards and from three to six sensors. Figures 4.2 and 4.3 show the basic "As-Is" build process for sensors and packages. In supporting the variety of products within PCI, the organization is divided into the following five functional areas:

1. Production Control
2. Production Engineering
3. Manufacturing
4. Product Assurance
5. Design Engineering.

NOTE: The "As-Is" process addresses primarily the production and quality functions, but lists the other functions to assist the reader for better understanding of the interrelationships of the support functions.

1. PRODUCTION CONTROL

The Production Control function determines which orders are manufactured and when the orders are manufactured. During the production control process, manual device schedules and travelers are released to control production on the shop floor. Manual device schedules are updated by production personnel for status feedback to production control. The schedules are used to generate manual ship and sales reports when the build cycle is completed.

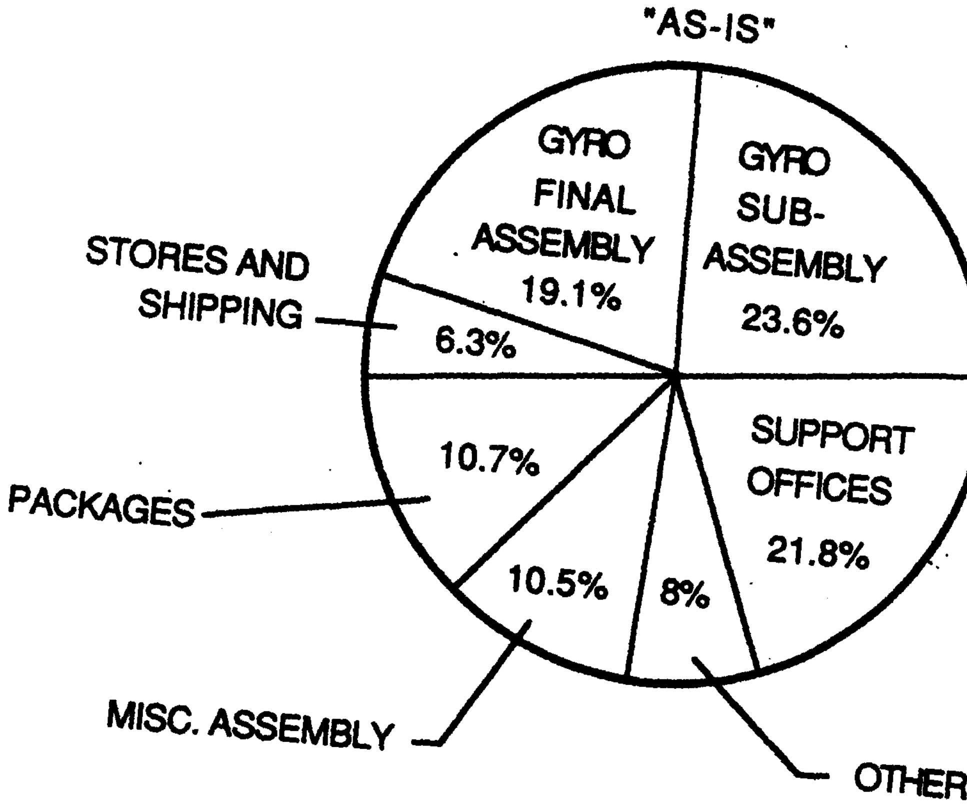


Figure 4.1. "As-Is" PCI Space Distribution

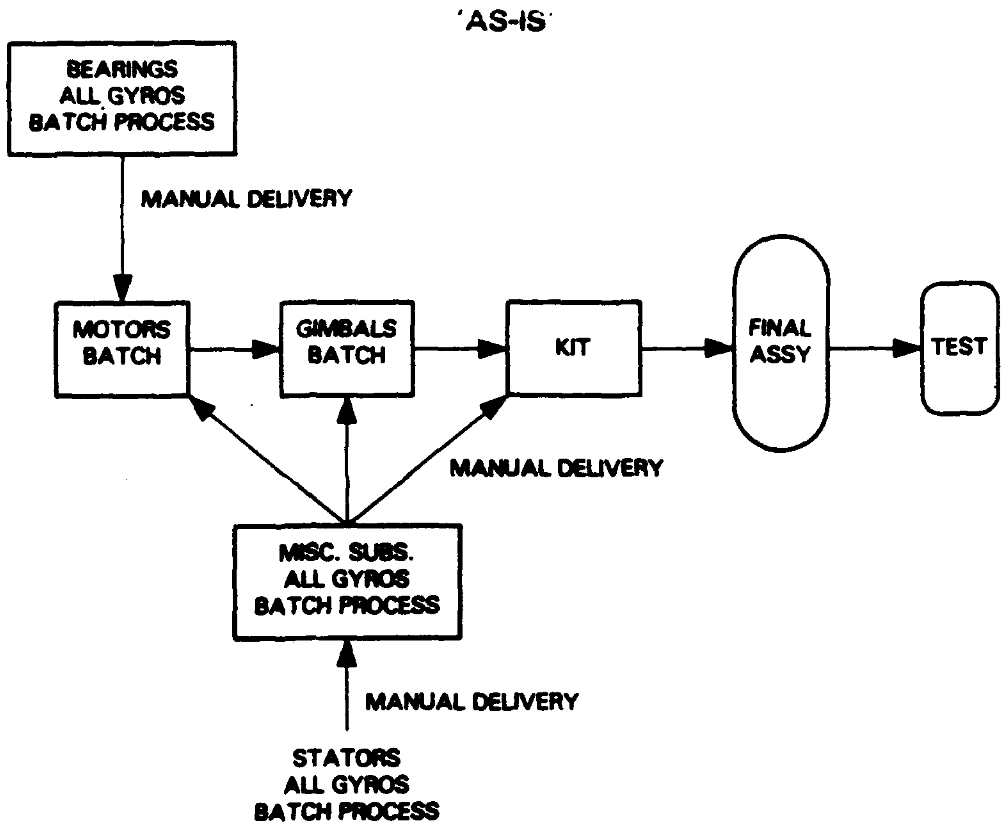


Figure 4.2. "As-Is" Gyro Assembly Process

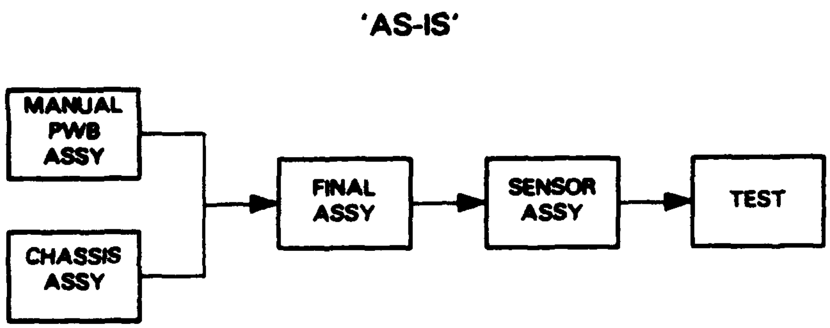


Figure 4.3. "As-Is" Package Assembly Process

2. PRODUCTION ENGINEERING

Production Engineering is responsible for the technical support function to the production area of PCI. These support activities consist of: a) process generation for new products, b) process maintenance on existing products, c) manufacturing technical support, and d) preparation of quotations for new or ongoing business. The prints and processes used by Production Engineering are manually revised, distributed, and stored. Production Engineering is located in a remote engineering office area which is anywhere from 50 to 900 feet away from Production Engineering's respective line area. See Figure 4.4 for the facility layout.

3. MANUFACTURING

PCI Production performs assembly operations on gyros, accelerometers, and electronic sensor packages for the PCI business. PCI manufacturing is typically divided into the following five functional sub-areas:

1. Build components area
2. Build sub-assemblies area
3. Assemble devices area
4. Assemble packages area
5. Test devices area.

(Figure 4.5 identifies the interaction, interfaces, and controls of the As-Is Manufacturing Process, Figure 4.6 is a listing and breakdown of the As-Is PCI personnel and historical manpower for the production department.)

Material together with work orders are manually moved to the appropriate functional sub-areas (i.e., bearing room spinmotor build area, package build area, etc.) by stores personnel. After receiving the material and work orders in the respective sub-area, the goods such as, material, components, completed subassemblies, and devices are moved to the predetermined work stations for processing and work assignments by production personnel.

The flow of material through the PCI production area typically follows a random movement through the sub-area for a given device. Typically, the flow of materials through PCI follows this general sequence:

- General stores to work areas for components, subassemblies, and assemblies.
- Winding products to the Spinmotor and Sub-Assembly areas.
- Gyro subassembly products to the spinmotor and gyro final assembly build areas.
- Precision bearings to the spinmotor area.
- Spinmotor subassemblies to the gyro final assembly build area.
- Gyro final assembly products to the final inspection/test area.
- Package assembly products to the final inspection/test area.
- Gyro final inspection/test to the package assembly area or to general stores.
- Some components and devices move to and from the Fab Fac area (located in the same building) as required for in-process work.

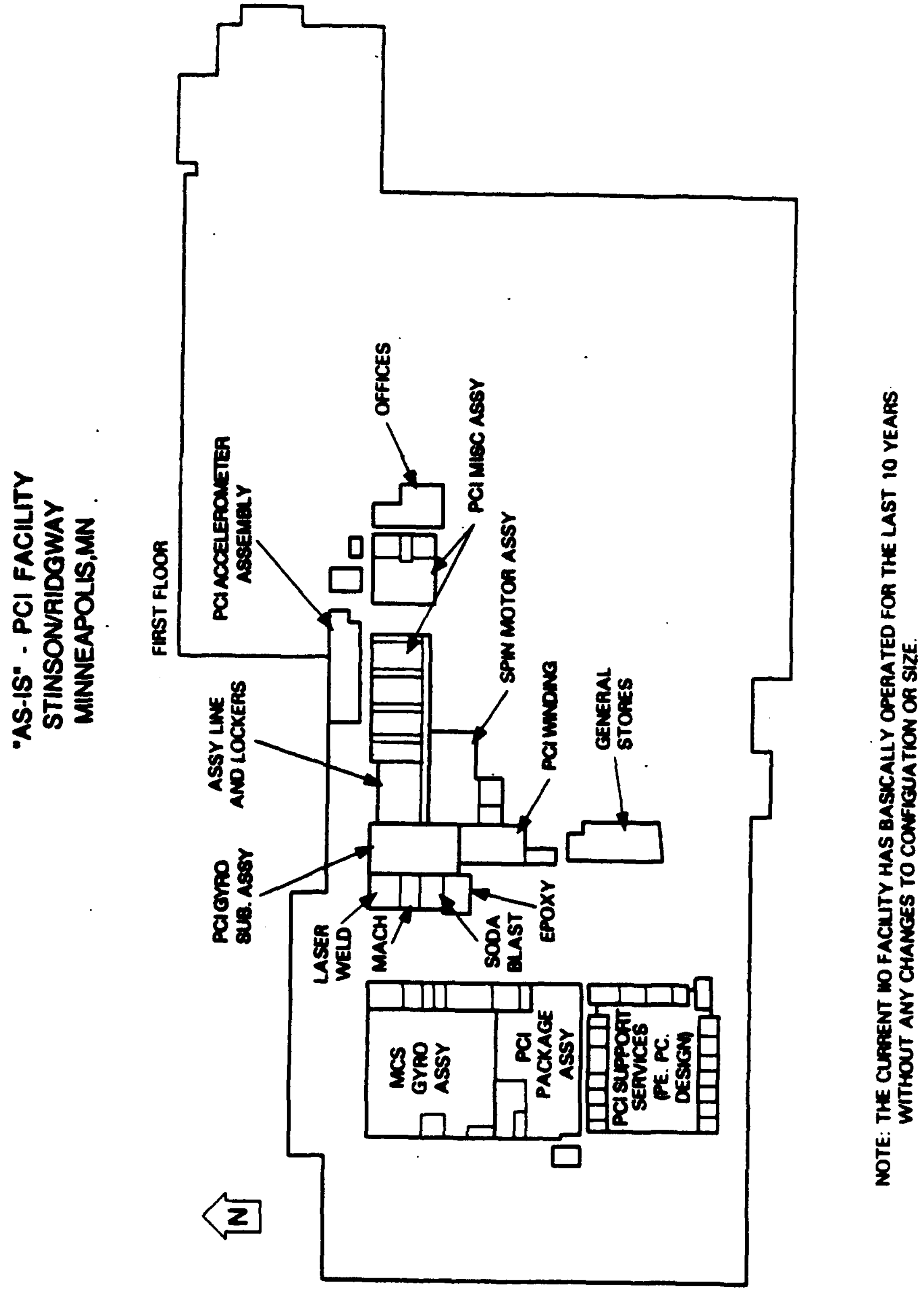


Figure 4.4. "As-Is" PCI Manufacturing Facility

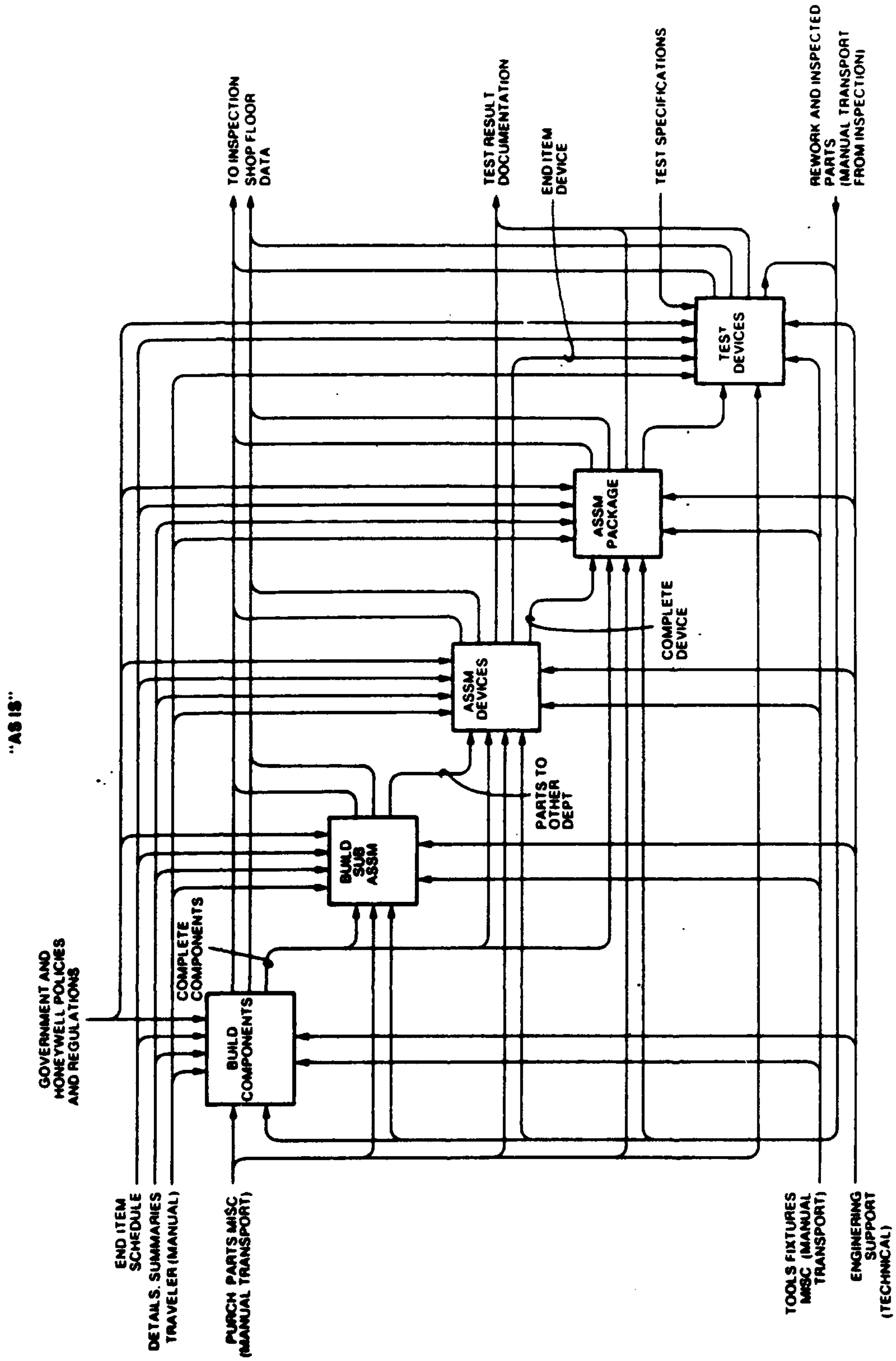


Figure 4.5. "As-Is" Manufacturing Process (PCI)

PCI PERSONNEL

NO	DEPARTMENT	% OF TOTAL
1.	Production	62.70
2.	Production Engineering	7.00
3.	Production Control	5.05
4.	Quality Engineering	2.65
5.	Inspection	7.70
6.	Design Engineering	1.60
7.	Marketing Contracts	2.40
8.	Costing Estimating	1.05
9.	Finance/Accounting	2.10
10.	Material Handler	1.05
11.	Stores	0.80
12.	Shipping	0.00
13.	Maintenance	1.60
14.	Industrial Engineering	0.30
15.	Information Systems	1.60
16.	Instrument Lab	1.30
17.	Other	0.55
18.	Department Management	0.55
	Production Total	62.70
	Support Services Total	37.30
	GRAND TOTAL PCI	100.00

Figure 4.6. "As-Is" PCI Personnel

Figure 4.7 shows the material movement of a typical PCI device within the PCI facility.

The assembly work as performed in the five sub-areas is described below:

3.1 BUILD COMPONENTS AREA

3.1.1 Winding Area

Representative gyro subassembly components produced in this area are signal generator pickoffs, torquer windings, spinmotor stators, gimbal cups, and balance pans.

3.1.2 Small Precision Bearing Area

The operations performed here involve cleaning, lubricating, and inspecting of all bearings received from outside vendors.

3.2 BUILD SUB-ASSEMBLIES AREA

3.2.1 Spinmotor Build Area

The operations performed in this sub-area are: assembly of gyro spin motor bearings, retainers, rotors, miscellaneous epoxied parts, and other spinmotor related subassemblies. Additionally, gyro spinmotors are also tested for preload, balance, and (where required) temperature cycling of components.

3.2.2 Gyro Sub-Assembly Area

This sub-area prepares cables for gyro interconnections, performs tie-off operations for coil cups/ pickoffs/stators, installs stator pins to stators, mixes epoxy compounds, performs potting operations, manufactures pickoff assemblies, assembles headers, and sets the gyro pivots. Additionally some in-process machining operations are performed. Figure 4.8 depicts a typical gyro assembly.

3.3 ASSEMBLY DEVICES

The device assembly area is the final assembly location for most of the gyros and accelerometers produced by PCI (i.e., GG1111, GG4400, LA2060, LA206, GG445). The area is a class B (approximately class 100,000) clean room and is temperature and humidity controlled. Some of the more precision processes are performed at class G laminar flow benches that are filtered down to 20 particles per cubic foot (class 100 and better).

The assembly area basically is divided into dedicated areas supporting the individual product lines, yet some of the common operations are shared among the programs by using the same facility, equipment, and work stations. This leads to a relatively complex flow of material and products that frequently changes from product to product and within the various product groupings.

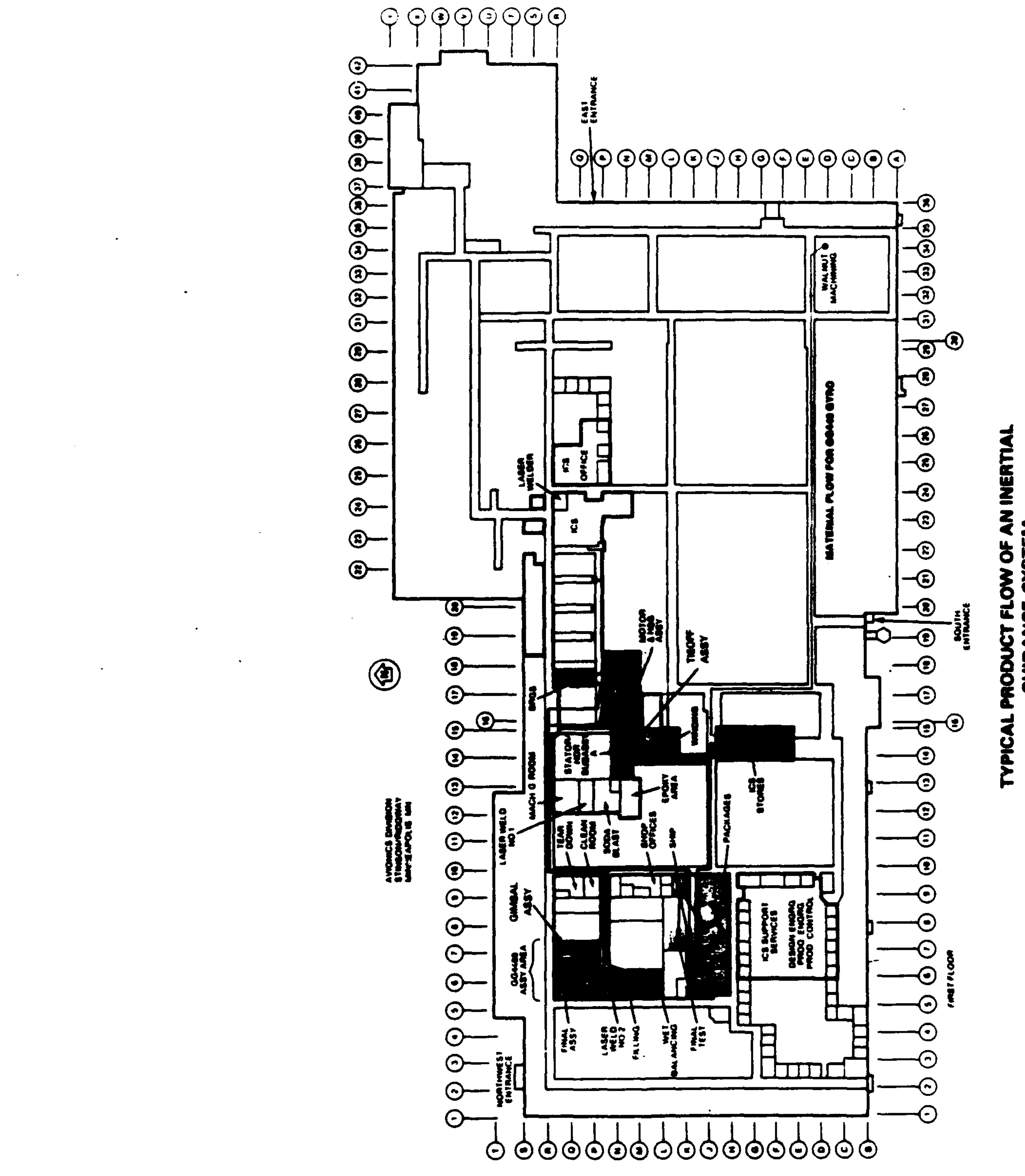


Figure 4.7. "As-Is" PCI Facility

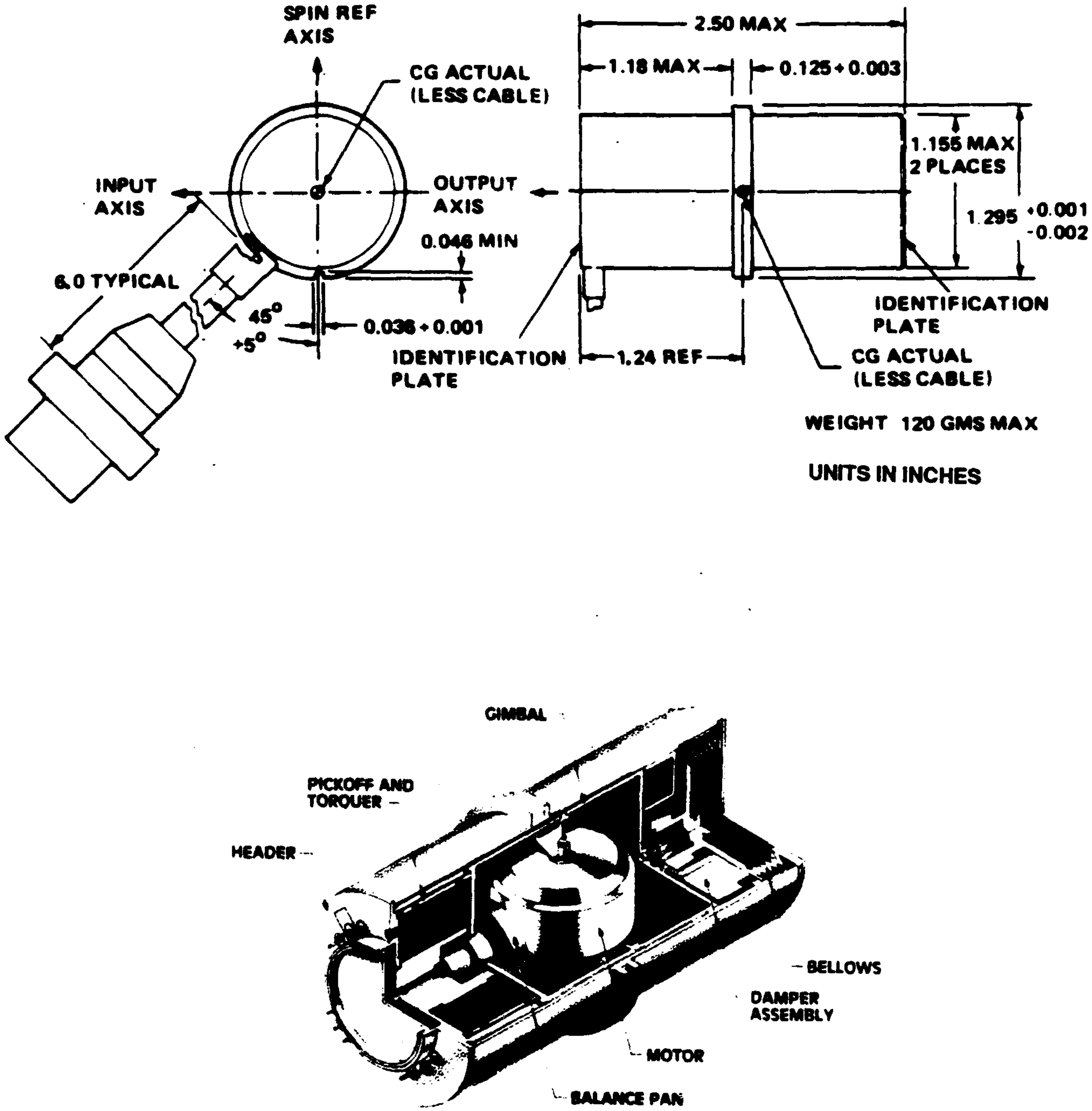


Figure 4.8. GG1111 Rate Integrating Gyro

Material handling within this area typically is performed by group leaders or operators, and production control personnel. With few exceptions, all operations are labor intensive and require specialized operator skills to produce quality products.

3.4 ASSEMBLE PACKAGES

The package assembly area is responsible for assembling a variety of gyro sensors with the required electronic circuits, sensor mounting, and packaging, as specified by the customer.

In this area, electronic printed circuit boards are manually assembled and solder-connected with other electrical components or circuits. Sensors (accelerometers and gyros) are installed with the completed electronics into precisely machined mounting castings. The sensors are mechanically aligned and connected to the electronic assemblies through time consuming manual precision calibration processes.

3.5 TEST DEVICES

The final test area for testing final devices is located adjacent to the package assembly area. The majority of products have to pass a final acceptance test that is contractually specified by product type and performed on computer controlled automated test equipment (ATE).

The more advanced automated test equipment in PCI requires manual operator loading and unloading only; everything else is done through a computer program. Less advanced test equipment requires constant monitoring of the test process and manual documentation of data by the operator.

4. PRODUCT ASSURANCE

The PCI Product Assurance function is comprised of the following two basic activities: 1) Product Assurance Engineering and 2) Inspection. The basic responsibility of the Product Assurance department is to ascertain the customer's needs from a thorough review and comprehensive interpretation of the contractual requirements. Compliance to these requirements is accomplished through the implementation and adherence to internal Honeywell Policies and Procedures.

4.1 PRODUCT ASSURANCE ENGINEERING

The Product Assurance Engineering department is responsible for generating Inspection Procedure Instructions (IPI's), Quality Work Authorizations (QWA's), providing corrective action reports, reviewing production process summaries and details, and developing acceptance test requirements. In addition, the department assists in Material Review Board (MRB) dispositions, participates in failure analysis, monitors corrective actions, conducts customer and vendor audits, provides production and inspection support, provides training for the inspection staff, and reviews inspection requirements. Product Assurance Engineering reacts to customer orders, inspectors, vendor requests, and customer/government audit requests. The group is governed by such basic documents as the Purchase Order and the Product Assurance Policy and Procedures Manual.

4.2 INSPECTION

The Inspection department has the responsibility to monitor the status and condition of the products in-process against the specified requirements and internal controls. Inspection identifies to the production department the areas which require corrective action. The inspection department also continually audits the factory and monitors air quality in the PCI clean rooms, and adherence to ESD requirements.

The in-process inspections are performed at specific points, as defined in the production process summary. These points are located at logical points in the production build cycle and include visual, mechanical, electrical, and final inspections. The visual inspection is utilized to identify obvious defects such as incorrect solder, incorrect component placement, and physical damage. The mechanical inspection checks dimensional tolerances. The electrical inspection tests electrical characteristics of sub-assemblies and functional characteristics of the finished product. It deals with ambient testing, environmental testing, and operational checks using ohmmeters, voltmeters, and manual and automatic test equipment.

Another function of inspection is to close out all paperwork before shipping. They perform minimal inspection of labels, name plates, and appearance before shipment. The inspectors are assigned to a given area and, in general, have backups who are cross-trained and capable of handling the various inspection functions.

PCI COST DRIVERS

The PCI business is labor and burden intensive. Labor costs are high as compared to material costs with burden being higher than the material costs. These cost distortions relate to the complex and delicate manual processes which are performed under clean room conditions by operators with very special know-how. Since conditions change during manufacturing processes, manufacturing is usually assisted and supported by all support services to meet internal and external schedules. This results in a high percentage of burden cost. Material cost is the smallest portion of the total product cost. By analyzing the factory costs further, work-in-process, operator inefficiencies, and scrap and rework repair account for the largest cost drivers. Next in line are factory overtime, factory indirect, wait/delay times, tool/equipment downtime, breaks, and an unusually high shop lead time.

PCI EQUIPMENT AND COMPUTER SYSTEMS

PCI utilizes various types of equipment and control systems during the build process. Figure 4.9 depicts the average age of PCI Equipment, which typically is used in the manufacturing process of devices. Laser welders, balancers, and microscopes are primarily used during the assembly of gyros and accelerometers. The ATE stations are used for both automated package and sensor testing. Ovens are used for curing of epoxied parts, whereas temperature chambers are exclusively used for environment testing. Rate tables provide forcing functions to gyros and accelerometers and are used for G-Testing of those devices.

EQUIPMENT	EQUIPMENT AGE FROM - TO	AVERAGE AGE
RATE TABLES TEMP. CHAMBERS ATE STATIONS OVENS LASER WELDER BALANCERS MICROSCOPES	1 - 35	14

Figure 4.9. Average "As-Is" PCI Equipment Age

PCI uses computer controlled equipment in the areas of Test Equipment and Laser Welding. Personal computers (TRS-80 and Apple) are used by Department Management, Production Engineering, and Product Assurance. They use modified generic programs to produce local control reports and for statistical information in quality.

Some of the advanced computer systems proposed/utilized by PCI that will interface with this Project include the following:

- Honeywell Manufacturing System (HMS). A packaged, integrated manufacturing system including inventory record management, manufacturing data control, MRPII, master production scheduling, purchased material control, capacity requirements planning, shop floor control, and statistical order forecasting. This project is being accomplished through close cooperation between Honeywell MAvD and the Honeywell Information Systems (HIS) Group which developed the HMS package. HIS is involved in the project to ensure that the special government-related needs of MAvD are satisfied by HMS. A current MAvD pilot program in a user area is being used to test the HMS package and develop the necessary modifications. The result of this close cooperation will be the development of a manufacturing package that will meet the special needs of MAvD and other government contractors.

- Process Management System (PMS). A custom-made Production Engineering tool designed to allow on-line entry and modification of parts lists and detail summaries.

- Factory Data Collection (FDC). A custom-made system designed to automate factory data collection through the use of data entry terminals and bar code readers. It is to be integrated with HMS to increase data collection efficiency.

- CAMAID. A series of CAD/CAM/CAE projects to automate design and Production Engineering tasks. These include plans to integrate and automate the design-to-production transition.

SECTION 5

"TO-BE" PROCESS

The Precision Control Instruments (PCI) business area is located in the Stinson/Ridgway. facility. PCI is part of the Inertial Instruments Operations (IIO) and designs and builds precision navigational devices and systems for commercial and military applications.

ITM Project 51/52 responded to problems which have surfaced during the Phase I and Phase II analysis and typically addressed problems in the following areas:

- Process Related
  - Redundant operations
  - High scrap rates
  - Long throughput times
  - Extreme process times
  - Inefficient techniques in assembly and testing
  - Balancing of spin motor and gimbal
  - Redundant machining and touch ups
  - Reduction of dirty operations
  - Consolidation of processes
  - Simplification of processes
  - Automation vs. manual processes
  - In-line vs. off-line operations
- Design related (internal list of improvements)
- Changes in make/buy and supply strategies
- Planning and control of manufacturing functions
- Consolidation of work and office areas
- Testing and inspection of devices
- Handling of parts and material through the factory
- Availability of information and data for the shop floor
- Tracking of material and inventory levels
- Documentation and recording of data

To address these problems, the PCI's production areas have been consolidated into one location and moved to the center of the building, and adjacent to the Ring Laser Gyro (RLG) area, the Fabrication Facility (FAB FAC) and next to IIO's Central Stores area (see Figures 8.20, 8.21 and 8.22). The production area is divided into five individual workcenters or assembly lines (GG1111, GG4400, Gnat, Packages, and Miscellaneous) and an area for bearing preparation. This breakdown has been chosen due to great differences in design, build sequence, processes and build-quantities of the various devices (Figures 5.1 through 5.3). Support personnel are co-located and occupy offices integrated into each of the assembly lines. (Note, this report addresses the GG1111, GG4400, Gnat, and Package lines due to their financial feasibility. The miscellaneous line has been segregated physically due to the minimal improvement opportunities identified in the preliminary design effort.)

Supporting the variety of products in PCI, the organization is divided into the following functional areas (the Design function is not included):

1. Production Control
2. Production Engineering
3. Manufacturing
4. Product Assurance

Figure 5.4 through 5.8 depict the peculiarities of processes and process flow of the four assembly lines (Note: Device LA 2060 is integrated into the GG4400 Workcenter).

1. PRODUCTION CONTROL

The Production Control activities have been computerized and rely on the Honeywell Manufacturing System (HMS) for Planning and Control functions primarily on the factory level and the Workcenter Manager (WCM) on the shop floor and workcenter level. The powerful computer systems which are used in conjunction with a Local Area Network (LAN) communication system, provide workcenters and workcells with on-line and real time information and process data at request or at scheduled intervals. The system structure is designed towards a paperless factory concept at a later date.

HMS is an advanced MRPII Production Control and Planning System and provides each workcenter and assembly line with data for Master Production Scheduling, Inventory Recording, Data Control, Materials Planning, Capacity Planning, Purchase Material Control and Production Cost Accounting. As part of the computerization, the department is further using a Process Management System (PMS), which is a computerized process layout system and the Factory Data Collection System (FDC) a material tracking system. At a later date, a Computer Aided Process Planning (CAPP) system or Factory Vision will be added in PCI.

HMS communicates with the other Systems through a hierarchical system structure and CIM-like design. The Controlling System of each workcenter or assembly line is the WCM whose backbone is a super micro computer, workstation terminals on each workstation and a high speed communication network. The WCM provides workcenters and workcells/workstations with the necessary information and controls on workcenter scheduling and dispatching, tracking of material through workcenters and cells, it manages manpower and product build history,

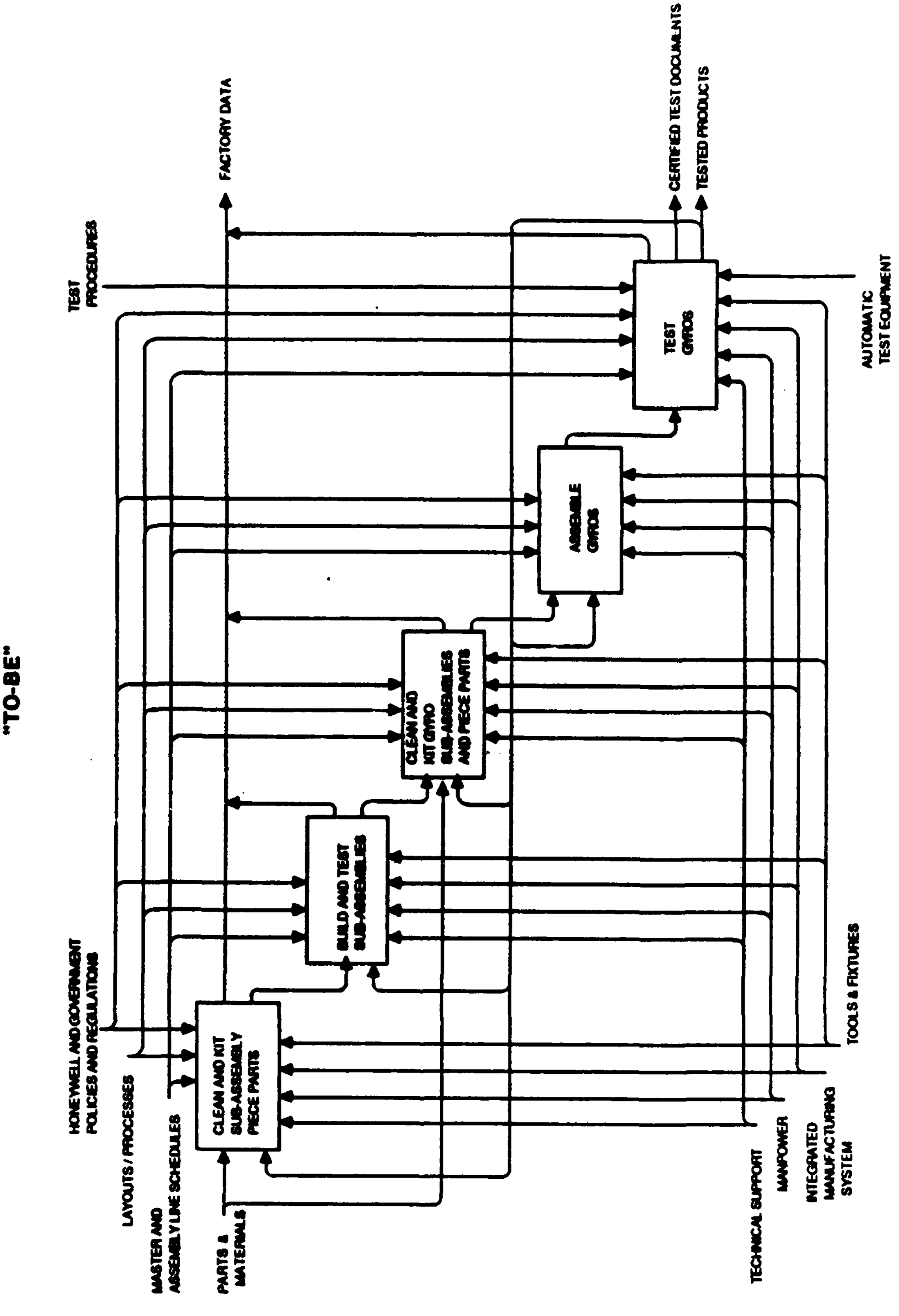


Figure 5.1. "To-Be" GG1111 IDEF

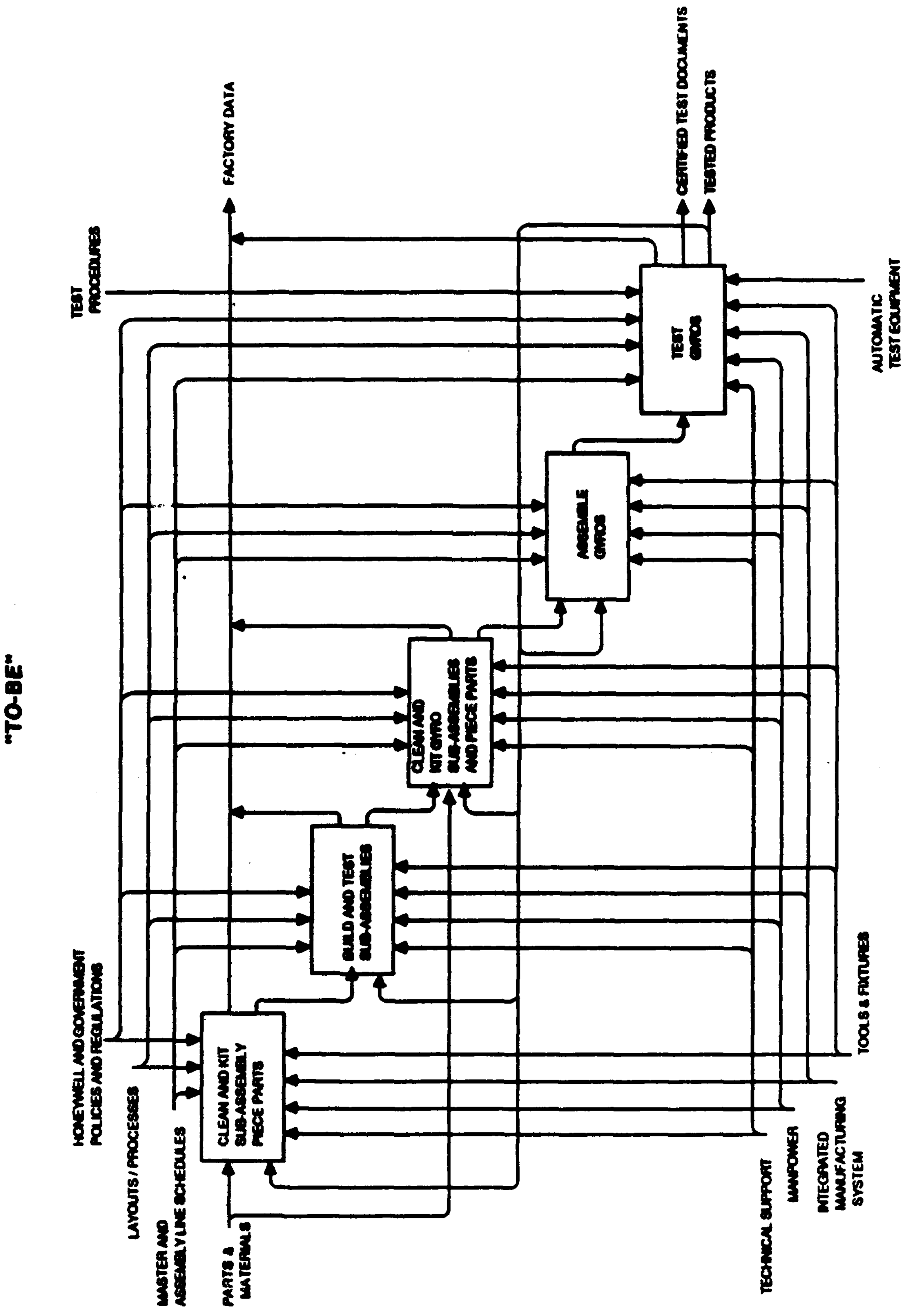


Figure 5.2. "To-Be" GNAT/GG4400 IDEF

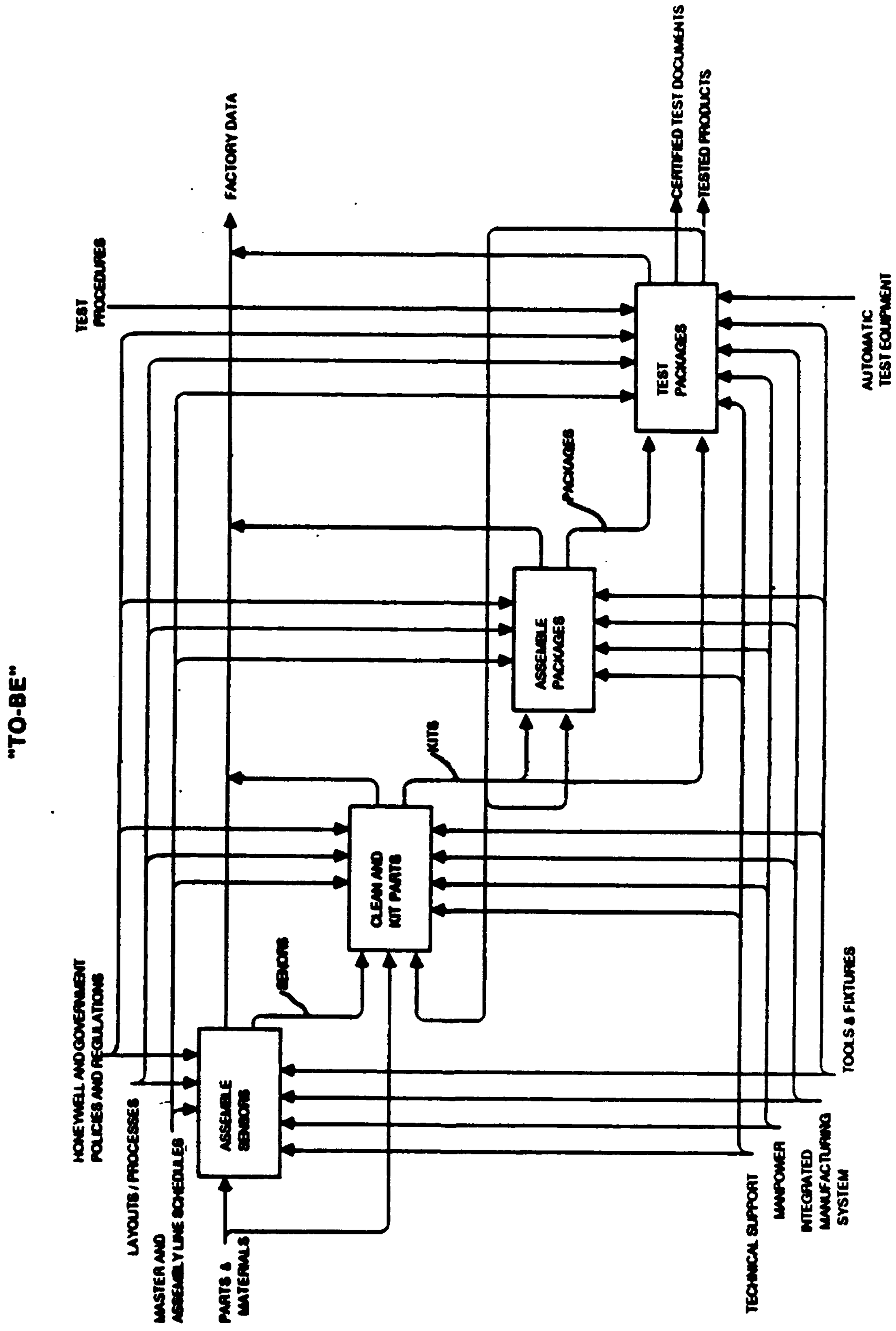


Figure 5.3. "To-Be" Package Line IDEF

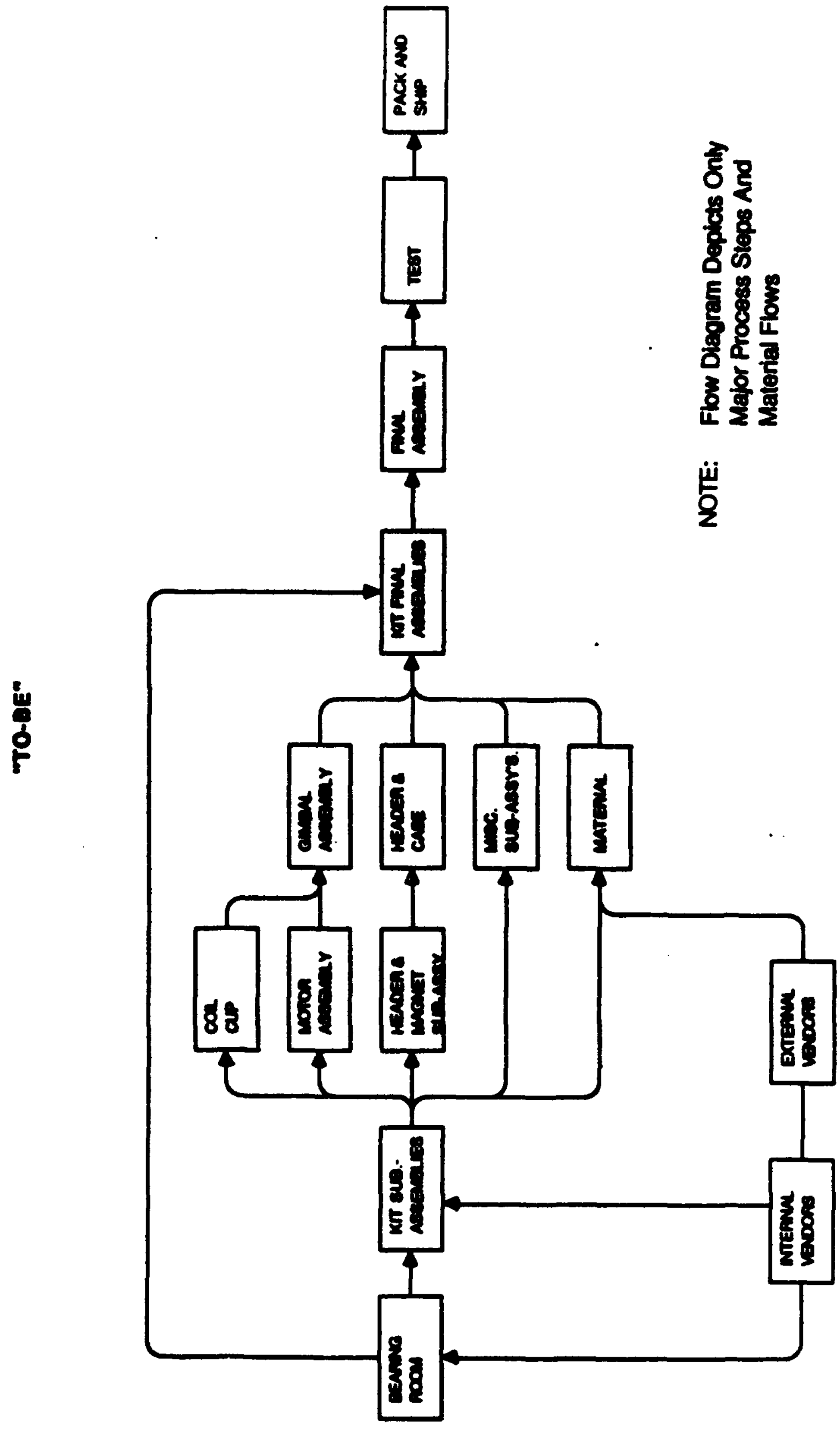


Figure 5.4. "To-Be" Process Flow of GG1111Device

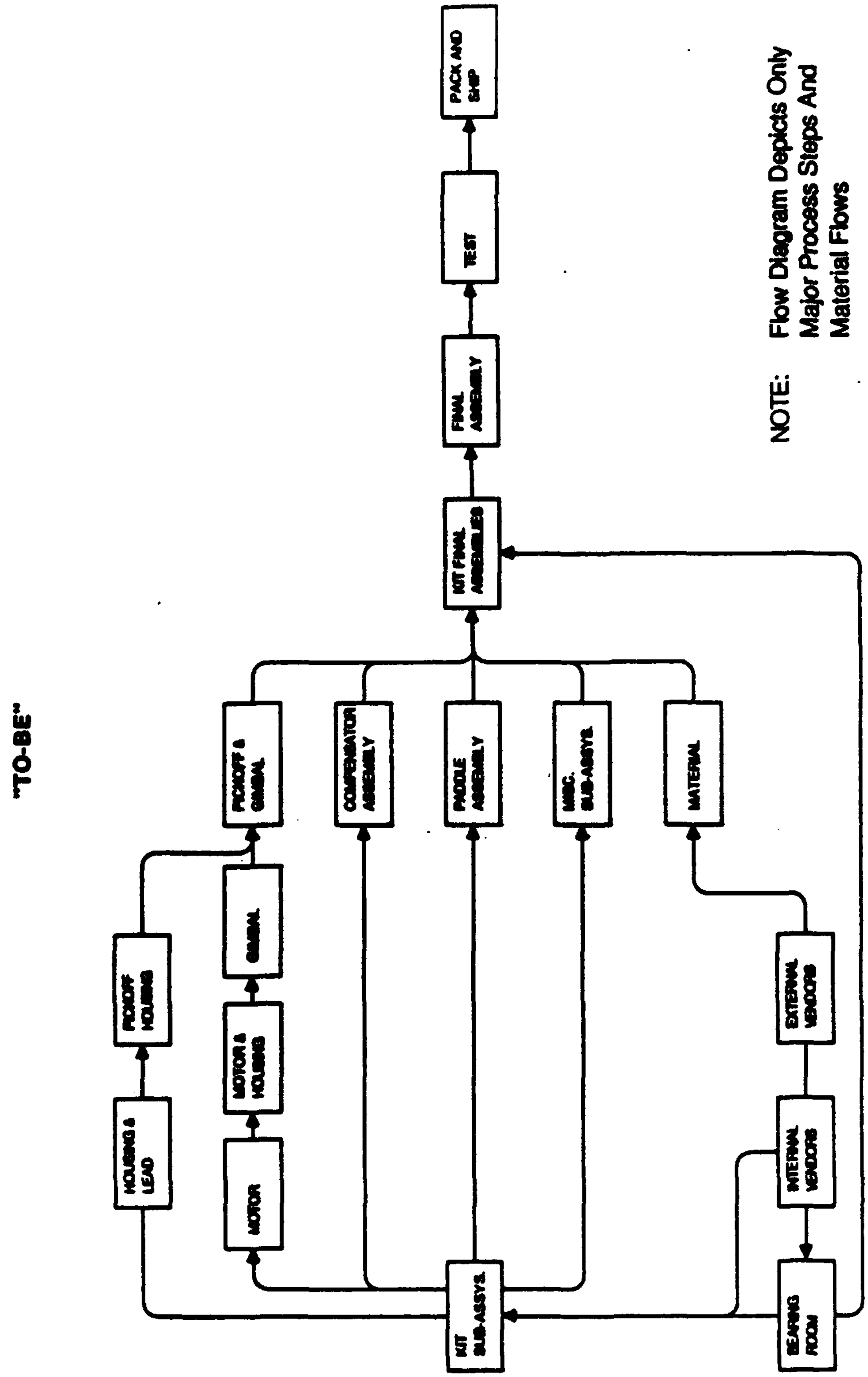


Figure 5.5. "To-Be" Process Flow of GNAT Device

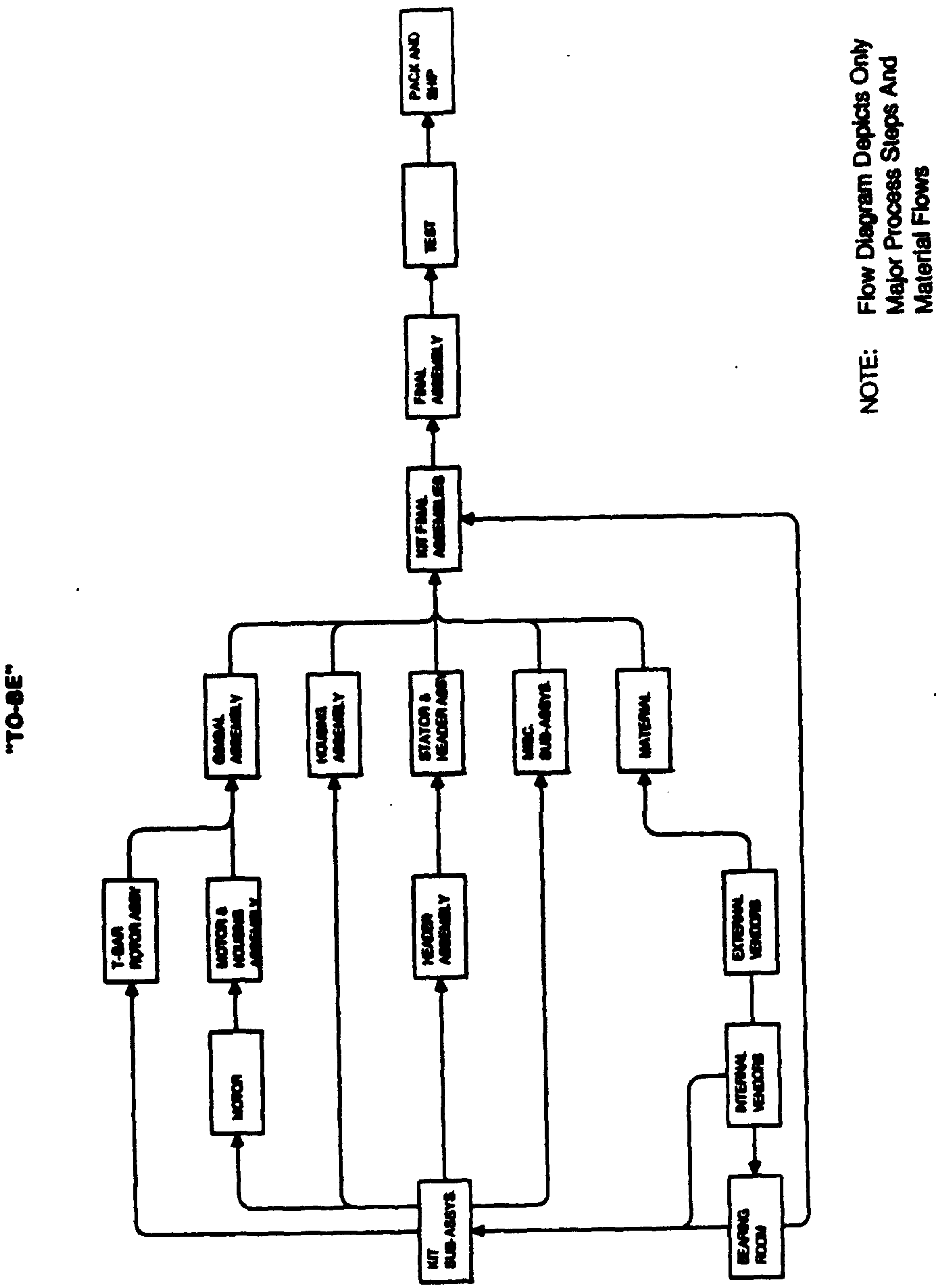


Figure 5.6. "To-Be" Process Flow of GG4400 Device

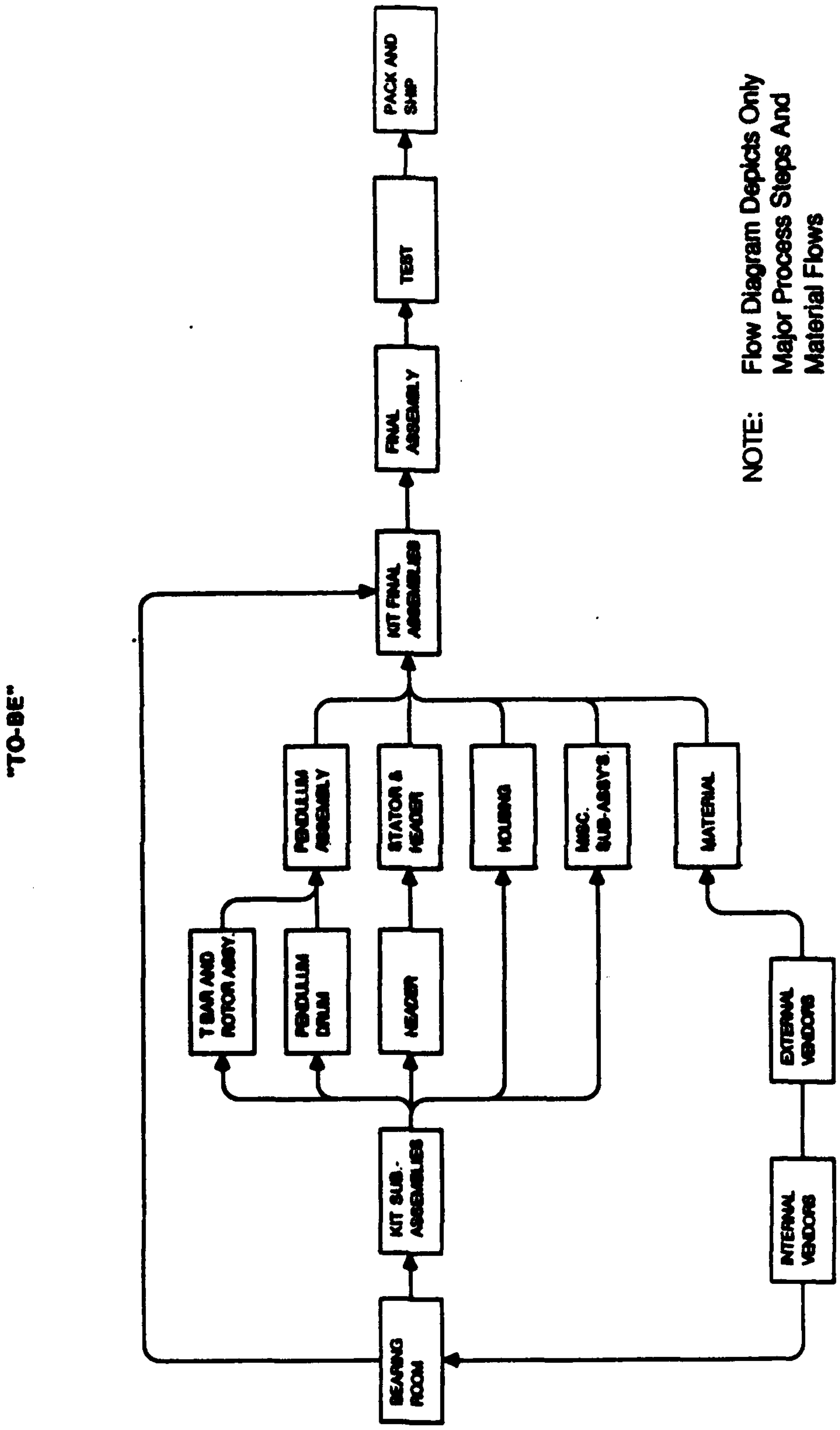


Figure 5.7. "To-Be" Process Flow of LA2060 Device

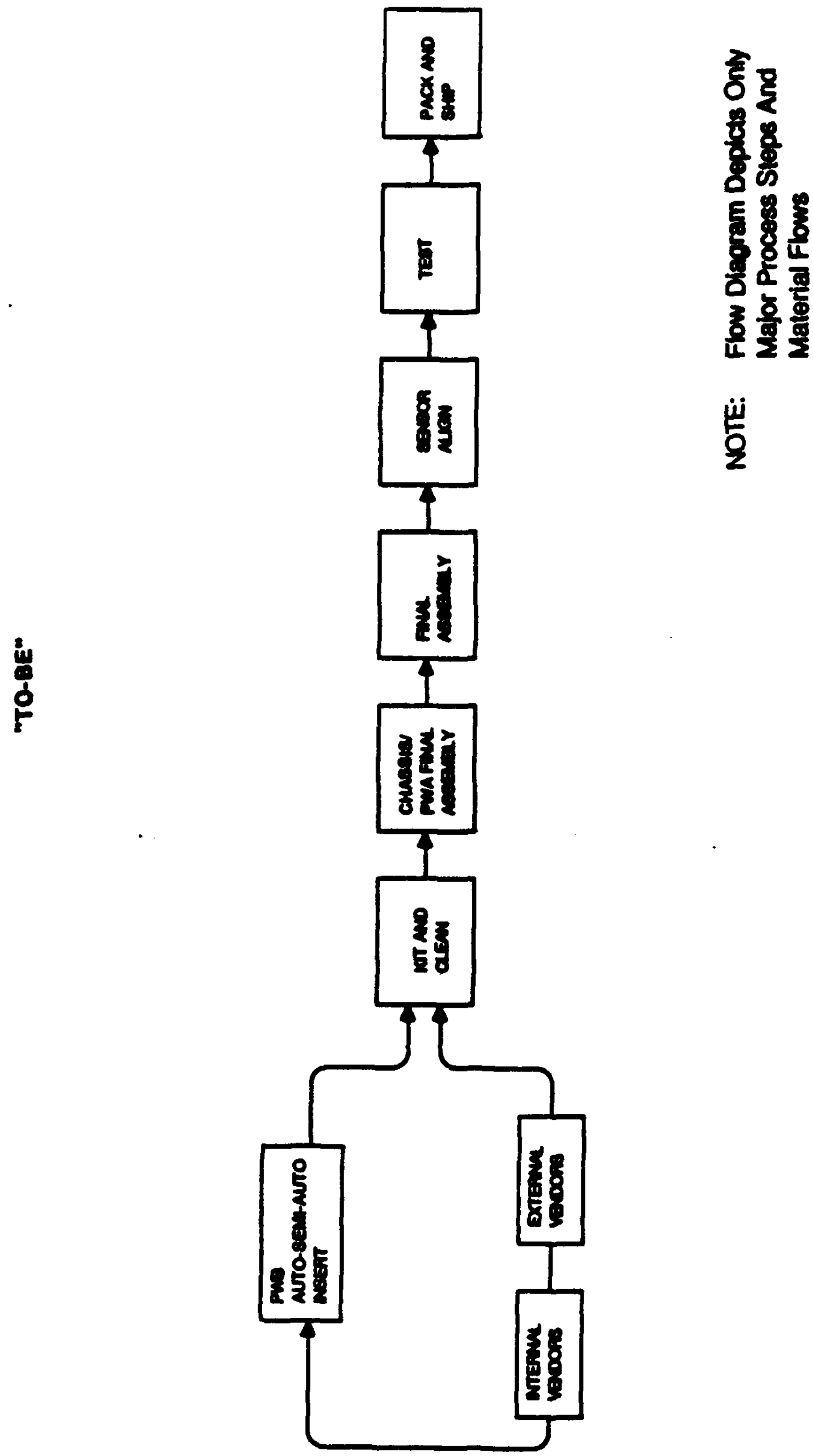


Figure 5.8. "To-Be" Process Flow of Package Assembly

interfaces with the Computer Aided Design (CAMAID) database and centrally stores the production and quality data which are vital for each of the assembly lines. The primary system for pacing the assembly lines is the WCM which is also the base for the installed Just-In-Time (J.I.T.) material control system on the factory floor.

Real time data and effective controls provided by the systems have eliminated expediting of parts, have reduced the total shop and system lead time and have increased the workcenter efficiency. The Production Control department is split by assembly line, in order to more effectively execute their function. The total amount of time spent on production control activities by shop and production control personnel has been reduced as demonstrated in the CBA. Overtime in the shop and by production control personnel is greatly reduced due to efficient daily schedule, real time feedback and the just in time material and control system.

2. PRODUCTION ENGINEERING

Engineers are organized into product-related assembly line teams, joining engineers from the other support service departments such as Design Engineering and Product Assurance. The teams also include Production Control and Production supervisors. The engineers are dedicated to only one assembly line. The teams are located adjacent to the respective assembly line and can oversee the line and its progress.

Production engineers typically perform the following activities: generate new processes, maintain existing processes, assist in preparing customer quotations, and provide effective technical support to the assigned assembly line. Prints and parts lists are available on data bases for on-line inquiry. Production process layout/instructions are generated, modified, and transmitted on-line through data links and engineering CRT's. Processes are based on standardized and cost effective designs; common parts and processes are available from a master computer list and may be easily called up on a CRT for quick reference or use.

3. MANUFACTURING

The Production environment has been modernized, enhanced and many of the manual processes have been automated. Operator efficiencies and factory output has been increased through the implementation of four segregated assembly lines (GG1111, GG4400, GNAT and Packages), which are paced to cycle times specific to each line and are equipped with dedicated and specialized equipment. A computerized, Production Control and Planning System, which is explained in Section 13, has been chosen to take over scheduling, data communication within workcenters and cells, parts and material tracking and the many planning and recording functions within each of the lines and the PCI-Factory. The elimination of older and low volume product groups from the four modernized assembly lines made the streamlining and standardization of assembly line processes and material flows easier and more efficient. The new factory operates with little inventory and work-in-process and receives necessary parts and material once or twice per shift from the modernized IIO central stores area (ITM Project 20) via Automated Guided Vehicle Systems (AGVS). Parts and material are received in preparation, or so called buffer areas, for verification, cleaning, and/or minor processes (laser welding, wire prep and others), and kitting or parts and material for subassembly lines and the final assembly line. Each of the four assembly lines has its own buffer area with the exception of the GG4400 and the GNAT area which share one buffer (due to smaller GNAT assembly line).

Each individual buffer area manages its own material supply via workcenter computers and the factory guide MRPII-Material Requirements and Planning System 'HMS' (see Section 13). Kitted material is dispersed from the buffer to each individual subassembly line to the final assembly line and the returned goods (RG's) area via tiered supply conveyors. After arrival at individual receiver lines, material moves on the paced conveyors. These conveyers, which are paced to the cycle times of each workcenter, unload the completed product to a return conveyor which delivers the assembly back to the kitting area of the buffer. The cycle is repeated until the final sensor is finally received in the buffer area again for final inspection by inspection personnel (bottom of buffer area, Figure 8.22) and ready for shipment to the shipping area.

The manufacturing area is divided and organized into five independent areas with assembly lines dedicated to the following proposed product groups/families:

- Bearing assembly area (this area is not part of Tech Mod but is briefly referenced below)
- GG1111 sensor assembly line and workcenter
- GG4400/GNAT sensor assembly lines and workcenters (share one buffer)
- Packages assembly lines and workcenters
- Miscellaneous device and gyro lines

The miscellaneous line has been segregated physically due to the minimal improvement opportunities identified in the preliminary design effort. Thus, the study was terminated on this line after the preliminary design phase and the line was taken off the modernization program.

In the modernized "To-Be" Factory, manufacturing basically performs the following activities:

- Cleaning and assembling of sensor and device bearings (one area, Figures 5.9, and 5.10).

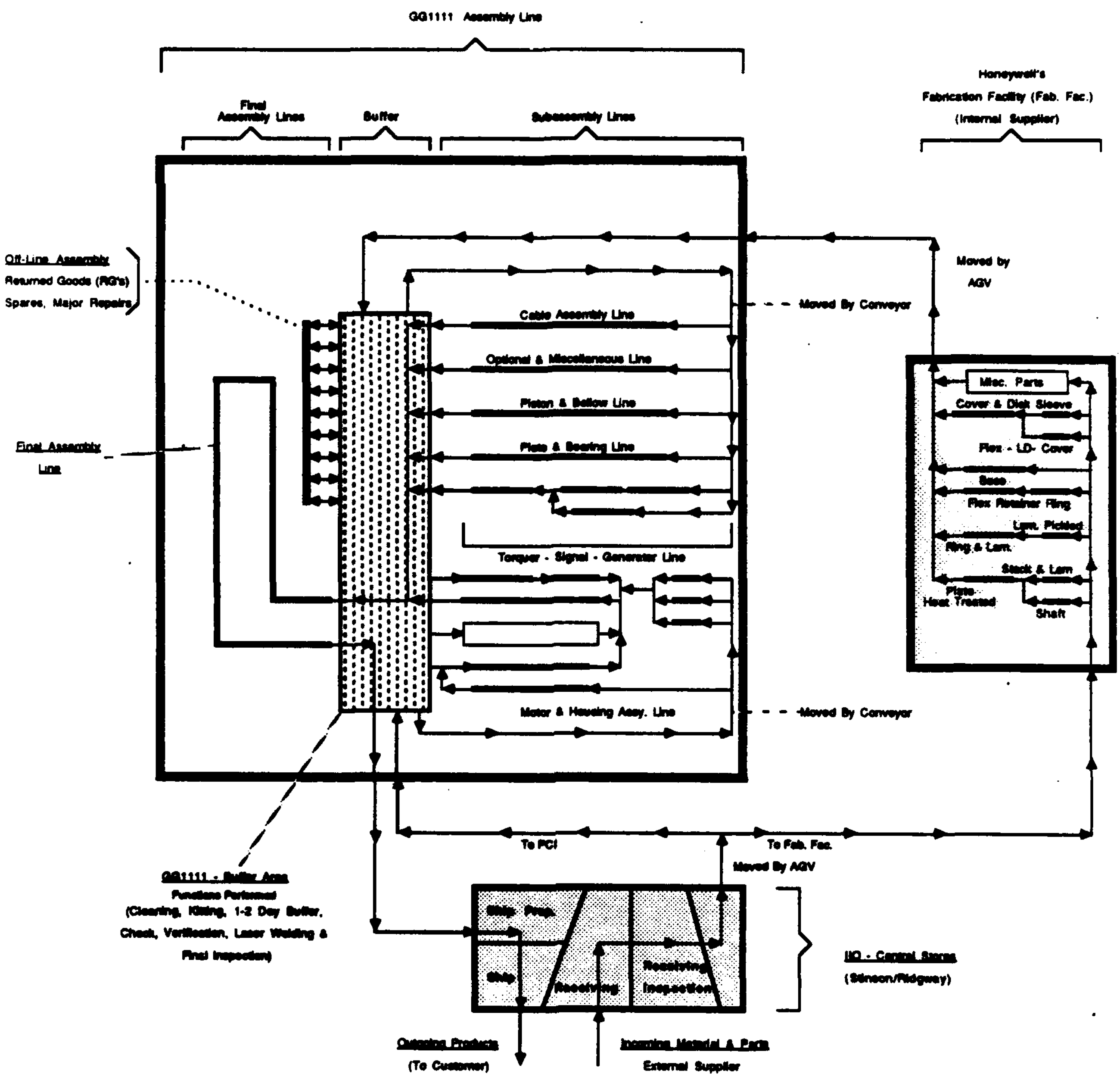
- Assembly of devices (separated by device type, Figure 8.20)

  - GG1111
  - GG4400/GNAT
  - Miscellaneous (excluded from modernization program)

- Assembly of packages (one area, see Figures 5.11 and 8.20)

The three device assembly areas are divided into:

- Preparation, cleaning and kitting activities (buffer)
- Subassembly and in-line machining activities (subassembly areas)
- Final assembly and testing activities (final assembly area)
- Final inspection
- Returned goods (RG's), spares and major repairs (off-line in final assembly)



Legend:
- Boxes Indicate Functional areas
- Lines with Arrows Indicate Material Flow
- Bold lines in assembly areas indicate entire Sub.or Final Assembly Lines (Not Workstations)

-Shaded Areas:
- Material/Parts Supply Areas
- GG1111 - Buffer Area

(Note: All Workcenter Internal Handling is performed Via Conveyors & Pneumatic Tube Systems)

Figure 5.9. "To-Be" GG1111-Manufacturing Concept

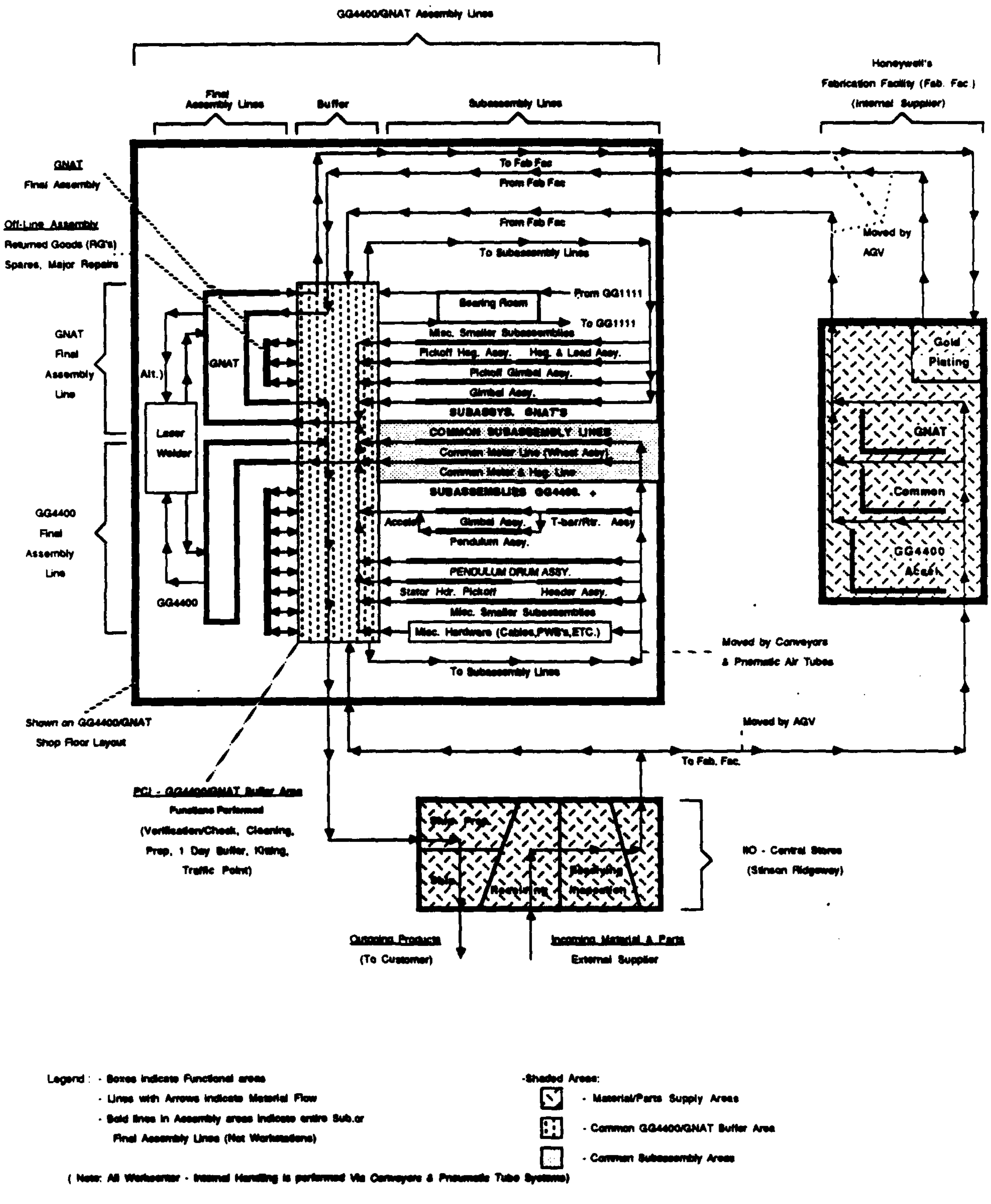


Figure 5.10. "To-Be" GG4400/GNAT - Manufacturing Concept

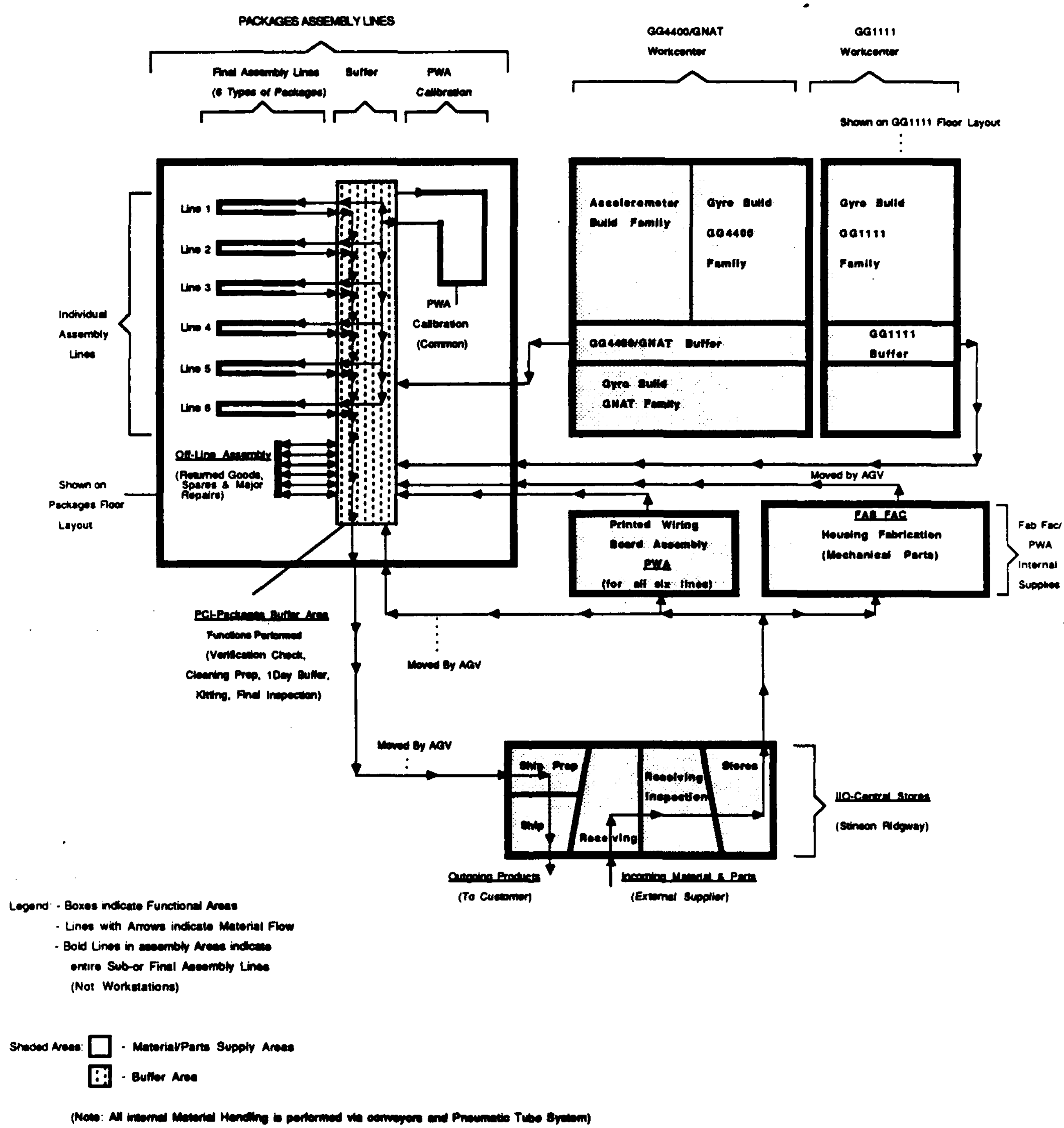


Figure 5.11. "To-Be" Packages-Manufacturing Concept

The packages assembly area is segregated by package type (a total of six lines) and divided into the following functional areas:

- Preparation, cleaning and kitting activities (buffer)
- Final assembly and testing activities (final assembly area)
- Final inspection and data collection (buffer)
- Returned goods (RG's), spares and major repairs (off-line final assembly)
- Printed wiring board (PWB) subassembly (final assembly area)

The GG1111 and the GG4400/Gnat assembly areas contain high speed assembly lines and are laid out for high production volume (over 1000 units per month). Both lines are designed based on a two shift operation. In contrast, the packages assembly is laid out for a one shift operation based on low volume (less than 50 units per month).

Flexibility and continuous line flow is the trade mark of each of the new assembly lines and is designed into the floor layout and workcenter logistics. With the exception of the packages area, all assembly lines are single and paced assembly lines. The packages area contains six individual assembly lines as explained prior. All lines and workcenters are paced to a cycle time which is common for the workcenter, and which guarantees the required annual capacity of each line. This concept allows for smooth production and optimal utilization of personnel and equipment. The six packages lines (within the workcenter) are paced to the individual requirements of each of the six package types.

All inspection, checking and testing operations are integrated and are in-line with the continuous assembly operations. Most of these inspection steps are performed by operators using semi or fully automated inspection and testing devices (table top and stand alone equipment) as called out in the newly developed "To-Be" layout details and summaries. As described previously, the material handling activities within, and to and from each product area and assembly line is coordinated and automated with the paced lines, and completely controlled from the buffer area.

Machine operations, as far as still required, have been integrated into the continuous line flow. Most of these machines are highly specialized and are dedicated to only one operation and line (they are not shared with other lines). This concept eliminates detours to the fabrication facility (FAB FAC) and a subsequent disruption of the continuous process flow. Through consolidation efforts and changes in make/buy arrangements, parts which still required major machining have been channeled to FAB FAC before they arrive at buffers of each assembly line (see Figures 5.9, 5.10, and 5.11). These changes eliminated lengthy queues and major delays in the assembly process and subsequent time consuming efforts by support personnel. As a result, shop lead times could be reduced by several weeks per product line.

Many of the manual operations have been consolidated into fewer process steps and then executed by highly automated in-line, dedicated equipment and devices. The use of bar code readers in conjunction with these pieces of equipment, especially for setting it up, has reduced the equipment set-up to close to zero. These enhancements made rapid changeovers for new products or other types possible. They have increased the flexibility of the entire assembly line.

To make the automation pay off on these lines, some of the part designs had to be altered in the areas of dimensions, joints and in some instances, part configurations. Assembly joints which required lengthy curing of epoxy (sometimes up to 6 hours per joint) and needed cumbersome off-line curing ovens, have been altered for air or UV-curing adhesives. This step allowed a true continuous assembly flow, since the curing times now encountered were in fractions of minutes or just minutes. Major time savings came from the areas of parts cleaning, which at present, with lengthy shop lead times and dirty assembly environments, had to be repeated several times during the assembly cycle. The new "To-Be" factory therefore was designed with a cleaner shop environment for the assembly areas (clean rooms as shown on Figure 8.21) and with central cleaning stops performed in the buffer area prior to kitting. A clean room located in the respective buffer area of each line contains this function, and the cleaning process itself is performed in a robotized cleaning cell. After cleaning, parts, material and selected subassemblies are inspected and microscopically cleaned by operators (located in the clean room), and then hermetically bagged prior to transporting them to the kitting area. As a result, many of the redundant cleaning steps have ben eliminated and the assembly process has been streamlined.

Standard parts are used in the GG4400/GNAT area. Those are parts which are common between the two sensor types. One of those common parts is the spin motor assembly. Therefore, the Tech Mod Team decided to move the spin motor cell into the buffer area of both lines, thereby improving the logistics for on-time delivery of spin motor types to each line. In general the "To-Be" design is aimed at consolidating common processes into one single area, and improving utilization and logistics of each of the common workcells.

Each of the individual product areas is divided into subassembly areas, where all subassemblies are built, and a single line/continuous final assembly area. Each of these areas has a paced line (both subassemblies and final assembly), which starts out at the kitting area of the buffer and exits into the same area. Input and output to the line is controlled by computers and the operators in the kitting area. As previously mentioned, the buffer is the logistics center of all material movements in and out of the workcenters. The material stored in these short term buffer contain no more than a two day supply for the assembly lines. Consequently, all storage equipment is kept small, with an eye on speedy kitting and rapid supply to the lines. To meet the demand on capacity, the two lines, GG1111 and GG4400, are fast paced lines (less than 20 minute cycle times), whereas the other two lines are paced to intervals measured between one and two hours.

Assembly lines have been laid out for batch sizes of 'one' as the final stage. Batch sizes of 'one' typically provide the ultimate flexibility for assembly lines and fastest throughput. Therefore, this philosophy was adopted primarily in the sensor areas and is the basis for the "To-Be" design of the assembly lines. With this design, any combination and mixture of different sensor types is now possible without penalties or negative effects on line output or efficiency (for reference refer to Figure 8.22). Figures 5.9 through 5.11 depict the basic manufacturing system which has been applied on these designs. These Figures represent the concept, the manufacturing strategy, and material flows.

In Figure 5.11, 'Gyro Build' and 'Accelerometer Build' refer to workcells performing manual assembly tasks. Workstations with ergonomic features are used throughout assembly areas. To improve operator efficiency and reduce operator fatigue during assembly tasks, workstations and table top equipment are organized such that they will optimize time and motion study factors (reaches, locations, etc.). Power and hand tools are dedicated to individual workstations and placed at strategically important locations and in easy reach of operators. Power tools have been used whenever operator efficiency could be improved. Material which is used in the process (e.g. wire, adhesives, solder, etc.), is dedicated to processes and typically stored directly at workstations where it is used. Generally all work areas are temperature and humidity controlled, and special air filtration and clean room systems are used in selected areas of the subassembly and final assembly lines (see Figure 8.21).

As Figures 5.9, 5.10 and 5.11 demonstrate, each one of the assembly lines receives its parts and material from external suppliers via IIO's central stores area. Fab Fac as the only internal supplier, ships its machined parts directly to the buffer of each of the assembly lines. It is planned that ultimately all parts movements external to the workcenters will be performed by AGV's. Finished products are picked up from the assembly lines in scheduled intervals also by AGV's. Material handling internal to each assembly line has been explained previously. As part of the modernization program, the team has aimed for minimal material handling in all areas or by locating processes and functions so that material handling becomes negligible.

As explicitly explained in Section 13 of this report, all of the assembly lines are controlled by a powerful shop floor planning and control system (HMS and WCM) which are aimed at a paperless factory and non-manual shop floor control system. Production requirements are typically received via HMS and scheduled and executed by the Workcenter Controller, and the Workcenter Manager (WCM) Scheduling and Planning System. These systems transform the "To-Be" PCI Factory in an electronic scheduling, planning and recording environment, and are equally used by Production Control, Production Engineering, Quality Engineering and Inspection, Management and Operators. Run down or status meetings, as they are known from the "As-Is" environment, are drastically cut through the output of real time and accurate computer/system information and data via computer screen or plotter.

Relevant and historical production data are collected by the Honeywell 'Factory Data Collection' System (FDC), which uses bar code and keyboard data entry or in some instances voice data entry from along the assembly line workstations. This data is then processed by the computer system and made available to engineers, inspectors, operators and managers by request. (FDC is not part of the Tech Mod effort in PCI, but through its divisional implementation, is available for the modernization program, and therefore has been used in the "To-Be" Factory Design. For further information see Section 13.)

Production Engineering is using the local area network communication system, which is part of the overall computerization of the "To-Be" Factory, to electronically transmit process data and process layouts directly to individual workstations. This "Computer Aided Process Planning" System (CAPP), uses the HMS and WCM hardware as host and data bank. It makes the up-to-date process data available to operators, by request, and is triggered through process and parts identification via bar code readers. Several menu levels are available to the operators depending on how much information is needed to perform the individual process tasks. The first menu only displays the process summary, highlighting the process/operation steps to be performed. The last menu level present pictures or video scenes of the operation selected.

As mentioned prior, the testing of devices and packages is performed in-line with the process flow and considering the line cycle time, the majority of test operations are performed on Automated Test Equipment (ATE) or on highly advanced table top testers. Manual testing of devices has been reduced to optional testing or testing of types with very low quantities. Bar code identification is used for identifying the device type prior to being tested, and for calling up the respective test program in the ATE-memory. With the aid of this technique, program set-ups on those testers are negligible and free the operator to perform the physical mounting and clamping of devices. The enhanced ATE's allow not only for automatic execution of the test sequence but also for recording results in a predetermined mode and in some instances by considering statistical methods, like "Statistical Process Control" (SPC) and other selected formats. All testers, especially the ATE's, feed their test results back to the data bank and the network of the workcenter manager. This feature allows easy dissemination of test data to the Quality Department and Production Management. Via printer, operaters receive the test results of the last test sequence immediately after the test is completed. For historical purposes and others, mainly audit related reasons, the test data remains in the mass memory of the WCM System for a predetermined time, and can be retrieved by request.

Support personnel such as, Production and Quality Engineers, Production Control and Production Management has been segregated by the assembly line area which they specifically support. These dedicated support teams have been located adjacent to their respective line (subassembly or final assembly) to shrink walking distances for support personnel and to make them an active member of the entire production area. Glass walls improve the closeness of operators and engineers and improve the working environment, and with the installation of two way communication systems between operators and support staff, shop floor communication has been greatly improved. These features have been selected to minimize or even eliminate delays in solving production problems on the paced assembly line. Ceiling mounted digital displays have been used at each line for displaying actual versus planned production output. Since the correctness of process data, tools, equipment and the proper execution of processes is crucial for reaching the calculated cycle time, emphasize is put on testing techniques and processes and training operators prior to moving them to the assembly lines. The line progress is constantly monitored by the support staff and corrections are made where needed to maintain a balanced and smooth line flow. Line flow and progress can be monitored via computer screens at each engineering workstation and corrections can be made immediately after irregularities are detected. Since process layouts are generated with the aid of the electronic CAPP system, corrections on those documents are immediately available on the shop floor. Many of these process descriptions are accompanied with descriptive graphics which can be displayed (in color) at the operator workstation.

4. PRODUCT ASSURANCE

The PCI Product Assurance function is partitioned into two basic activities: Product Assurance Engineering (PAE) and Inspection. The responsibility of PAE is to determine the customer's needs through a thorough review and comprehensive interpretation of the customer's requirements and specifications from the contract. Then PAE ensures that these requirements are satisfied by internal Honeywell implementing documents. Inspection also implements controls and processes with sufficient feedback to provide effective internal monitoring and auditing, thereby assuring compliance with all applicable specifications.

4.1 PRODUCT ASSURANCE ENGINEERING

Product Assurance Engineering (PAE) performs a multitude of functions. These include reviewing customer requirements and internal implementing documents for compliance, reporting vendor and internal inspection audits, monitoring and reporting corrective actions, and reviewing the production processes and material requisitions. They also develop acceptance test requirements, provide technical assistance to inspection and the Material Review Board (MRB), and generate inspection procedure instructions for use by each program as well as standard inspection procedures for use across multiple programs. All PAE actions are controlled by Honeywell, government policies and regulations embodied in military standards, and the Honeywell Quality Procedures Manual. These activities are performed by Product Assurance engineers, technicians, and clerks.

4.2 INSPECTION

The Inspection function, part of the Product Assurance department, is responsible for all in-process inspection, final device acceptance tests, process and test equipment certification, and quality audits. Inspection performs visual, electrical, functional, and dimensional tests. Electrical and functional tests are performed by certified automatic test equipment and test programs. Inspection also reviews test results and audits test equipment, procedures, and programs.

The nature of inspection and the inspection points are determined by PAE. These inspection points are indicated on production process summaries, which are available on-line. Inspections are performed according to on-line inspection procedures (related to one program) and/or standard inspection procedures (related to multiple programs).

Inspection and checking operations are integrated and are in-line with the assembly operations. These activities are performed by operators with very few exceptions. Also material handling within and from each of the product areas is automated and coordinated with the paced lines.

Production operators perform most of the in-line process verifications on the operations they have completed. Inspectors may perform a more complete product verification on selected assemblies.

The highlights of the "To-Be" inspection in the Product Work Groups are:

- In-line inspection stations as required for the new production processes. The parts are inspected or audits are performed as the assemblies proceed through the process with no queue required for the inspection operation and no additional material handling function to move parts to and from off-line inspection stations.

- Minimal visual inspection by building into the production processes the proper tooling and support to the production operators to eliminate the need for visual inspections. The emphasis is on auditing the production processes and operator training to assure that parts and assemblies as processed meet the print criteria.

- Emphasis on "State of the Art" no contact measuring equipment with data recording capability. Each part or assembly (as processed) is checked as part of the production process and the data is recorded and retained in the Work Center Manager (WCM) data base. This data will be audited to insure that the production process remains in control.

- Statistical process control is used on key operations in the production process to insure that critical dimensional and functional characteristics are maintained within the control limits. These production operations will be audited by inspection to insure that the quality levels remain consistent with the desired results.

- Automatic Test Equipment (ATE) is upgraded to include Failure Analysis capability. This allows total ATE results to be used in the final test of the product and to meet the necessary contractual requirements for acceptance or rejection. This data will also be retained in the Management Information Systems for future product evaluation to improve performance or fault isolate problems with field returns.

- The total quality control of the PCI products will be operated by a WCM which will not only serve production needs, but through the local area network will provide inspection and audit instructions to the operating and inspection personnel, retain quality data records, and generate the necessary forms which are used in the processes and required as supporting product documentation to the customer.

In the "To Be" factory, the emphasis will be shifted from product verification to Statistical Process Control to maintain a balanced line flow and place responsibility for product quality with the personnel who build the product. All in-process inspection will be performed by the production operators as part of the normal production process. Training of the production personnel in the use of equipment and proper visual criteria is key to the success of the production processes to produce high quality hardware.

Final acceptance of the product will continue to be the responsibility of the inspection department as well as the auditing of the production processes to insure that they are producing hardware to the desired quality levels on a consistent basis.When Inspection is noted on the Process Summary, the Inspector enters the part number on a computer terminal and receives the Inspection Record Card (IRC) printout which may include a list of:

- Released drawing part numbers.

- Standard inspection procedures.

- DCAS requirements.

- Customer requirements.

- Engineering change orders.

- Engineering specifications.

The inspector may use the following equipment to perform the inspection:

- Scopes, optical viewers, optical comparators for visual inspection.

- Scales, calipers, laser dimensional testers, etc., for dimensional inspection.

If the product is rejected, it is returned to production for disposition. Customer inspectors and DCAS inspectors receive certified inspection and test documents for their review. Occasionally, the accepted product itself will be reviewed by customer and/or DCAS inspectors to verify the accuracy of the certified inspection and test documents. After successful completion of all inspections, the product may be delivered to nameplating, stock, spares, or production for additional operations.

SECTION 6

PROJECT ASSUMPTION

The following assumptions have been incorporated into the development and implementation plans for the Project. Alternatives or deviations to these assumptions could have an impact on schedules and/or costs to the implementation of the Project.

- Capital funds will be available when required by the Implementation Plan.
- Precision Control Instruments (PCI) department will make resources available in a timely manner for the implementation effort.
- The Implementation Plan will consider the GG1111, Packages, GG4400, and GNAT product groups. The Miscellaneous Area is not included due to unfavorable study results.
- The GG1111 product group will lead the implementation effort.
- Factory space for the GG1111 product area will be available for implementation in the third quarter of 1987.
- Implementation of the Factory Modernization will be carried out in two steps. The first step will be a low-tech approach primarily using "As-Is" equipment and processes but using a factory shell designed to the "To-Be" requirements. The second step (addressed in this report) will complete the modernization effort through exchanging "As-Is" process and equipment with proposed "To-Be" process changes, equipment, tooling, and systems.
- The Inertial Instruments Operations (IIO) Stores area is capable of supplying material and parts to various product areas without time delays.
- The implementation of all PCI product areas will be completed in accordance with the PCI Implementation Master Plan.
- Production, Design, and Product Assurance/Quality engineers will finalize process and design changes prior to implementation and will pilot critical processes to minimize the risks for production.
- Factory space for the Packages, GG4400, and GNAT product groups will be available by mid 1988.
- The paced line buffer area will be organized and constructed to the final "To-Be" design during the step one implementation with the exception of high dollar capital items (Laser marker, etc.).

- Clean rooms, social areas (restrooms, breakrooms, etc.), shop offices, support offices, utilities, ESD-floors (Packages), etc., are constructed to the final "To-Be" design prior to the step one move.

- The bearing room will be upgraded per PCI requirements during the second implementation step and will supply to the various product groups in a timely manner.

- Internal material handling systems, especially permanent installations, will be implemented and tested during the interim period of the first and second implementation steps.

- Materials, parts, and components will be supplied by subcontractors and vendors, including Fab Fac, in accordance with the "To-Be" Master Schedules and will meet the requirements for kitting and production.

- The Miscellaneous group/product area will be upgraded to a level as required for integration with the other product areas.

- Personnel changes, training, and other required corrections for line or staff personnel will be completed prior to the second implementation step.

- Co-location of support personnel shall occur during the first implementation step.

- Shop Floor Control Systems are piloted and tested prior to the second implementation step and then implemented and debugged in the final implementation step.

- Tool design and tool build (in-house) will meet the implementation schedule requirements.

- Product/process verifications are completed prior to the final implementation step.

- Test Systems and Logistics Operations (TSLO) will meet the step two implementation schedule regarding test equipment (new ATE's and modifications/upgrades).

- "To-Be" equipment, tooling, fixtures, etc., will be available when required by the implementation schedule.

- Existing laser welders will be located in the buffer area of the appropriate product work group and will be installed during the first implementation step.

- Existing workbenches/stations and office furniture are replaced by ergonomically designed and modern units as outlined.

- Computer CRT's (for FDC, HMS, CAPP, etc.,) will be installed in the following sequence: specific support offices and cleanroom-pilots in step one implementation, remaining support offices and factory in the second implementation step. The GG1111 will lead the effort.

- Selected subassembly areas (internal gyro parts) and final assembly areas (up to the fill process) will meet level B cleanroom requirements. Other areas will be humidity and temperature controlled.

- The #2 ATE test unit will be moved to the GG1111 product area during the first implementation step whereas the #1 ATE tester/balancer will remain with the Packages product group. Two additional downscaled ATE balancers will be added to the GG1111 product area during the second implementation step (presently under study by P.E.).

- New ATE test programs and ATE program updates are prepared simultaneously during the hardware build period and tested prior to shipment and use in the second implementation step.

- Support and staff personnel will support one distinct product group only - no sharing of equipment, space, or personnel.

- Factory Data Collection (FDC) and Honeywell Manufacturing System (HMS) will be implemented during step one implementation.

- The product work groups will operate on a two-shift basis and overload and surge requirements will be handled through third shift coverage.

- Implementation of the project will not require changes in the labor contract or practices.

SECTION 7

GROUP TECHNOLOGY CODING SYSTEM ANALYSIS

The application of group technology as an analysis tool was of limited use in Project 51/52 since products generally follow a distinct flow pattern within a product family and usually are of identical or similar design. Group technology analysis was only applied to the GG1111 product group.

The GG1111 product group is comprised of seventy-one (71) various device types which fit into eighteen family groups. Even though the various device types are nearly identical in product design, their specific processes and operation sequences still vary slightly. Also, each of the seventy-one device types required a different subassembly combination or different subassemblies altogether. This can be seen on the Bill-of-Material breakdowns (i.e., kites) in Figure 8.3 in the next section of this report.

In order to define a general process sequence for the final assembly line (and the gimbal subassembly) and determine the shop layouts for the "To-Be" factory, the team developed the computer matrix shown in Figure 7.1. The matrix, based on the group technology approach, has been used exclusively for defining a standard process flow primarily for the final assembly area. Figure 7.1 depicts the typical design of the matrix with product families listed horizontally (indicated by letters) and operations listed vertically (indicated by numbers in column 'A'). A product family typically contains several gyro types. Each gyro type within a family uses the code letters for that family (e.g., AJ, AK, LC, etc.) followed by a specific two digit numeric code referencing the gyro type (e.g., AJ01, AJ02, AJ04, etc.).

The processes of the AJ gyro types provided the original baseline for entering processes in the matrix. The listing of operations in column 'A' has gaps since operations of gyro types which did not follow the AJ sequence had to be inserted between AJ operations. Processes for other gyro types subsequently were added and integrated, step by step. As a result, vertical columns 'C' through 'T' contain all operations/processes which are possible on the GG1111 gyro.

Results of the analysis are displayed in the field below the gyro type listing and to the right of the listed operations. For easy reference, the following coding system has been used.

- "X": Processes are performed on all device types within the listed gyro type/family.

- Numbers like "08", "02", etc. define which of the device types follow the process sequence.

- If a code "All except 10, 20, 30" is displayed, it indicates the listed device types do not follow the process sequence.

- If a box is coded with "X/052A" (as an example), it tells that the particular operation shown on the left (e.g., 042A, Check Kit) is performed on all device types but under a different operation number (i.e., 052A).
- If none of the above codes are used and the box shows a "blank", it means that this particular operation is not performed for the listed device.

As a result of the matrix, a standard assembly line was developed which insured that this single line could accommodate all of the seventy-one GG1111 device types. Subsequently, a second step of analysis on the computer matrix was required. This second step is briefly explained below.

First, labor standards were added to the listed operations in order to pre-balance the listed operations. Operations made obsolete in the new factory (due to process improvements) were color coded and removed from the matrix. The remaining operations then were grouped by related processes (in sequence) and a first attempt was made to balance this generic line. In some instances it was necessary to combine a high number of operations into one group, especially if operations were performed for products with lower quantities and rare occurrence. This was done for optimal line balancing and equal work load among the workstations. It was imperative to include not only the standard operations into the standard line but also the optional processes and their operation steps to create a common assembly line with uninterrupted smooth flow.

Once the matrix was prepared, it was used in the development and design of the new assembly line and for the development of the new "To-Be" detailed processes.

	OP #	DESCRIPTION	AJi	AKi	LCI	GG1163AAC
2						10072320
3						
4	001F					
5						
6	002F		X	X	X	X
7	003F		X	X	X	X
8		HONEYWELL			X/004F	
9						
10	004F		X			X
11	010A					
12						
13	015A	PROPRIETARY			13,20	
14						
15	015M					
16	020A		X	X	X	X
17						
18		DATA				
19	020M					
20	030A		X	X	X	X
21						
22	030M					
23	030B		X	X	X	X
24	030C		X	X		
25	032A		X	X	X	X
26	035A		03-05,07,10-16,18,20,21		ALL EXCEPT 10,13,20	X
27						
28	035B		03-05,07,10-16,18,20,21		ALL EXCEPT 10,13,20	
29						
30	035C		03-05,07,10-16,18,20,21			
31	036A		03-05,07,10-16,18,20,21		ALL EXCEPT 10,13,20	X
32						
33	040A		X	X	X	X
34				X/041A		
35						
36						
37	041A		X		X	
38	042A		X	X	X	X
39	043A					
40	044A					
41	045A		X	X	X	X
42	047A		X	X	X	X
43	049A		X	X	X	X
44	050A		X	X	X	X
45						
46						
47	050M					
48	055A		X	X	X	X
49	060A		X	X	X	X
50	060S					
51	065A		X	X	X	X
52	070A		X	X	X	X
53						
54	070M					
55	075A		X	X	X	X
56						
57	075M					
58	085A		X	X	X	X
59	089M					
60	090A					
61	090M					
62	099A		X	X	X	
63	099S					
64	100A		X	X	X	X
65	100S					
66	110A		X	X	X	X

Figure 7.1. GG1111 Operations Breakdown by Gyro Family

SECTION 8

PRELIMINARY/FINAL DESIGN AND FINDINGS

The approach to the development of the final design of the "To-Be" factory has been described in the Section 3, Technical Approach.

At the onset of this project, the following objectives were established in order to meet the general objectives of the program and IIO's Strategic Plan: converting the existing PCI production facility into a modern and competitive production facility for tomorrow.

STRATEGIC OBJECTIVES AND GOALS

The strategic objectives and goals for Project 51/52 include:

- Reduce the manufacturing cost of products by 25 percent or more
- Reduce shop lead times from twelve plus weeks to about two weeks
- Improve product quality and increase yield rates. Goal: 98+ percent
- Reduce work-in-process and inventory by more than 50 percent
- Reduce set up time and equipment set ups by 75+ percent
- Improve on-time delivery and responsiveness to the market place
- Upgrade the level of manufacturing technology to improve competitive position in the market place
- Develop a modern and efficient manufacturing system which will lead PCI into the next ten to fifteen years.

Based on these general objectives, the factory design objectives were developed and applied as guidelines by the project team in designing the "To-Be" factory.

FACTORY DESIGN OBJECTIVES

Design objectives for the "To-Be" factory include:

- Divide the PCI production facility into four dedicated production areas (i.e., GG1111, GNAT/4400, Packages, Miscellaneous).
- Pace and balance each of the assembly lines for optimal output.
- Co-locate production teams and support personnel by individual product.
- Use a computerized master schedule and shop floor control system.
- Provide paperless data collection based on barcode identification and integrated computer data base coupled with a Local Area Network (LAN).
- Provide paperless dissemination of information to workstations and work cells via CRT's (Computer Aided Process Planning - CAPP).
- Centralize cleaning, kitting, material control, and logistic functions in each area.
- Automate equipment and tooling to a justifiable level.
- Apply Just-In-Time for parts delivery and movement.
- Institute in-line operator inspection.
- Automate material handling to, within, and from the shop floor.
- Automate and enhance in-process/product testing.
- Institute product audits at the vendor level.
- Provide incoming inspection and verification of all parts at the production facility site.
- Develop quality techniques/systems for early detection of quality problems.
- Institute total physical parts control system (real time).
- Use modular/ergonomical workstations for maximum line flexibility.
- Cross-train operators to assure a smooth continuous flow of hardware independent of fluctuations in the work force and/or product mix.

ANALYSIS

The design of the "To-Be" factory was based on a well structured and detailed factory analysis in order to meet project objectives. The analysis, which was performed separately on each of the four product areas, focussed primarily on analyzing production processes, manufacturing techniques, material and process flows, equipment and tooling, controls, and logistics. Specifically, the analysis was aimed at the following areas.

- Methods
- Processes and Techniques
- Product Design
- Equipment
- Procedures and Practices
- Standards and Performance Indicators
- Manpower
- Services and Service Groups
- Factory Costs
- Control and Information Systems
- Quality Systems and Procedures
- Scrap and Rework
- Shop and System Lead Times
- Make/Buy Strategies
- Floor Layout and Floor Space
- Strategic Planning (short/long range)
- Training, Skill Requirements, and Human Issues
- Management/Control Techniques.

The developed methodology initially was applied to the GG1111 product group. During this process, it became obvious that the study would benefit from input of the persons affected by the modernization project. Consequently, brainstorming sessions were conducted with shop and office personnel as a means to solicit and record viable information about the operation as well as to open up a dialogue with the end user. The detailed results were computer charted as shown in Figure 8.1.

These results have served as valuable guidelines for developing the factory design. Although the brainstorming results were generated primarily by the GG1111 product area, they were used by all project teams and have provided guidance for the entire design effort.

Next, the various product types were grouped into product families and further broken down to the subassembly level (see Figure 8.2). This structured organization aided the project teams in considering peculiarities of the various product families for the design of the "To-Be" factory. The matrix revealed a large number of product types for the GG1111 product area which were grouped into consolidated families. The matrix for the other product groups revealed less than the GG1111 product types. For the purpose of this report, the GG1111 product area has been chosen as the example for all of PCI's product areas.

To decide on which of the product types/families would be used as the standard baseline when developing the processes for the "To-Be" factory, a ranking of product types by past production quantities was generated. Initially, the ranking revealed that one gyro, with 25 percent of the total production quantity, was the high runner and therefore was chosen as the base model for the GG1111 factory design.

The next step involved determining if the ranked product types, especially the first five to ten , would be on the active list or on the obsolete list when implementation of the modernization program was completed. A marketing forecast was developed for the various product areas. From this forecast, it was determined that two gyro's would be leading the GG1111 ranking in the future whereas the present leader would disappear from the list because Honeywell management had decided to move production to another facility.

With the strategic outline well established, up-to-date bill-of-material breakdowns (kites) then were generated for more than a half dozen high ranking product types by using GAPOS, an in-house computer system (see Figure 8.3). These kites were used throughout the entire project as road maps for make/buy decisions, process/material flow patterns, proximity of assembly units to each other, "As-Is" lead times, vendor sources, and (most notably) cost related studies and calculations.

BRAINSTORMING SUMMARY

PROBLEM AREA	PROBLEM	SOLUTION	CODE	RATING PRIORITY	EFFECTED AREA	EST. COST $	[illegible] FOR TECH [illegible]	SPEC NO	ACTION/SPECIFICATION FOR TECH MOD	NAME RES. P.E	TIME DATE
1 PLANNING & SCHEDULING PROBLEMS	TOO MUCH TROUBLE SHOOTING CRISIS TO CRISIS O WHY DO WE TROUBLE SHOOT - LACK OF PRIORITY ON PREVENTION ACTIVITY - DEGREE OF RESPONSE NOT APPROPRIATE TO ACHIEVE SOLLUTION - LACK OF AWARENESS ON PART ON NEW OPERATION	NO PLANNING IN SCHEDULING					G				
		NOBODY FOLLOWS SCHEDULING					G				
		NO COMMITMENTS FROM FAB SINCE NO SCHEDULE IS AVAILABLE					T				
		SHIPPING SCHEDULE DRIVES ALL PRODUCTION ACTIVITIES					T/G				
		PACED + LINEAR FLOW					T/G				
		DEDICATED LINES AWAY FROM GG1111					G				
	LOW VOLUME ORDERS CAUSE EXCESSIVE FAB SET UPS O LOW VOLUME ORDERS	J.I.T. CONCEPT AS ANSWER					T/G				
		REACTIVE SCHEDULE, GUIDELINES					T				
2 COMMUNICATION PROBLEMS	BETTER COMMUNICATION BETWEEN P.E./Q.E. WHEN CHANGES ARE MADE, MINIMIZE IMPACT ON SHOP	SOS TO BE INCORPORATED AT SAME TIME BY PE/QE					G				
		SAME AREA/LOCATION FOR PE/QE, PLUS D.E					T				
		STREAM LINE/SHORT CUT SIGNOFF PROCEDURES, IMPROVE BOTTLENECKS					G				
		PUT EARLIEST/LATEST DATE IN E/O SYSTEM INSTEAD CUT-OFF DATE					G				
		CLEAN UP RELEASE SYS & MAKE USEABLE & REALISTIC					G				
		SIXTY DAY CHANGE OVER TIME VS. TWENTY DAY LIMIT					G				

Figure 8.1. Brainstorming Work Sheet

SUMMARY OF GG1111 PRODUCT FAMILY STUDY

RUNNING NUMBER	DESCRIPTION	NUMBER OF OPTIONS/VARIATIONS	ASSEMBLY TYPE
1	GG1111 - GYROFAMILIES (AJ, AK, LC ETC.)	14	A
2	TYPES OF GG1111 GYROS (ALL FAMILIES)	69	A
3	STATOR TYPES	14	SA
4	ROTOR TYPES	13	SA
5	MOMENTUM RINGS	11	SA
6	MOTORS	28	SA
7	COIL CUPS	19	SA
8	PAN AND HOUSING ASSY.	6	SA
9	BALL AND HSG. ASSY.	4	SA
10	GIMBAL ASSY.	42	SA
11	PRIMARY COILS	10	SA
12	HEADERS	21	SA
13	FLUX RETAINER RINGS	8	SA
14	GIMBAL BRGS.	3	SA
15	PORTED PLATE	4	SA
16	PISTON & BELLOWS	5	SA
17	CABLE ASSY.	29	SA

Legend:
Assembly Type: A - Assembly
SA - Subassembly

Figure 8.2. GG1111 Product Families (Final and Subassemblies)

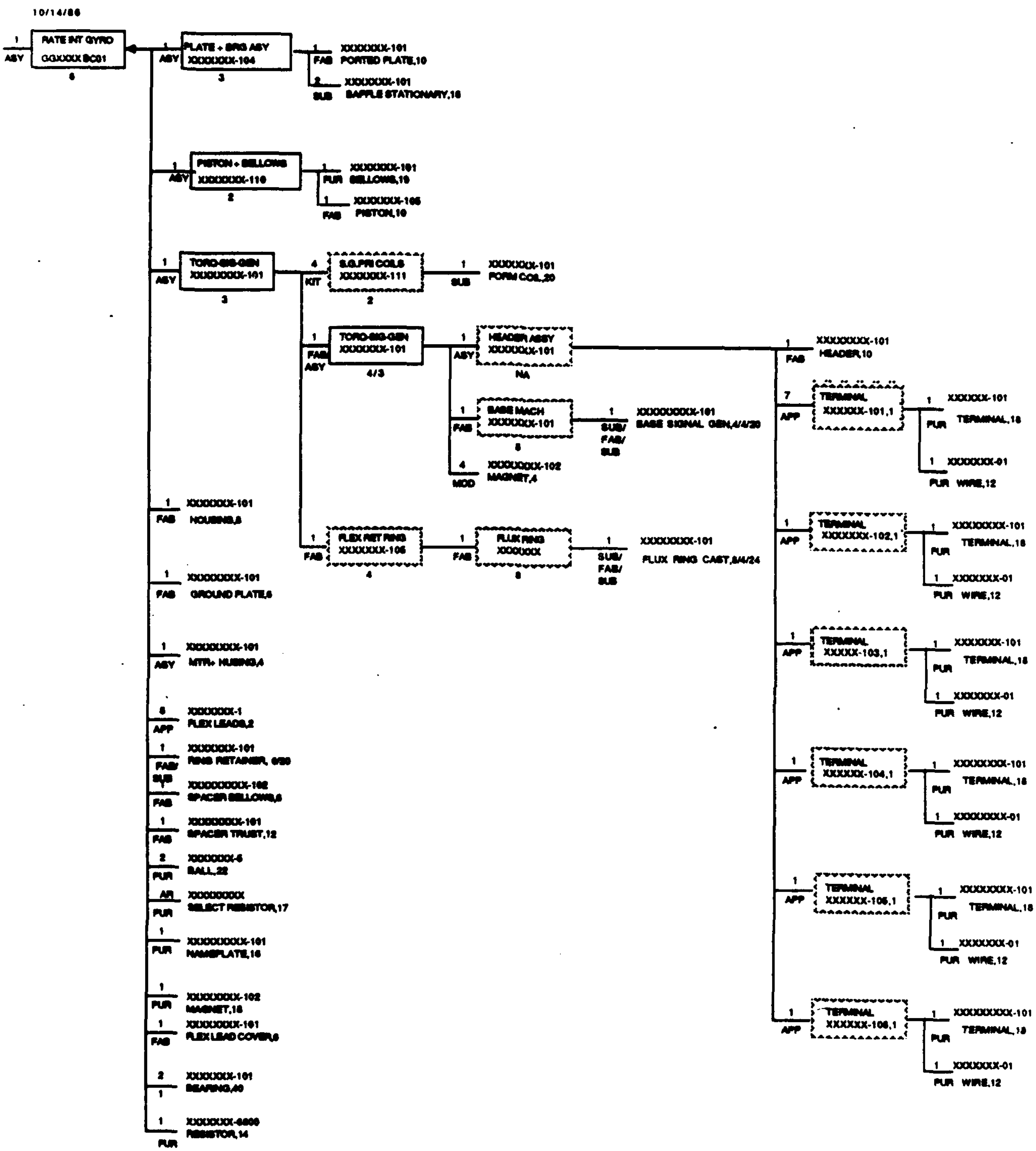


Figure 8.3. Kite (GGXXXX, Rate Gyro)

Following these basic steps, it was necessary to locate the cost drivers of the manufacturing process in order to subsequently pinpoint areas for improvement within the operation. Labor and burden costs comprise a large portion of factory costs. Consequently, the modernization effort focussed heavily on these issues in order to reach cost reduction goals and the required program justification. Emphasis was shifted primarily toward reducing the labor content of products and organizing support services and overall logistics for maximum efficiency. As a result, the following design strategy was developed.

- Simplify processes, material and information flow.
- Rethink and recreate manufacturing technologies and strategies.
- Emphasize 'going to the root' of problems and finding long-term workable solutions.
- Listen to everybody involved and filter out what can be useful.
- Use modern but basic production technologies.
- Use automated equipment and tools to overcome bottlenecks.
- Find long-term solutions to overcome short-term fixes/band aids.
- Emphasize planning versus quick fixes.
- Use manufacturing as the driver of the modernization effort.

Next, a listing of operations/processes was developed by product type, assembly, and subassembly. Color codes were established to distinguish among inspecting/checking operations, alternate operations, set up/handling/cleaning operations, repair operations, and value-added operations. See Figure 8.4 for a sample. As planned, the listing exposed redundant and non-value-added operations/process steps. These efficiency drains now could be analyzed further. Figure 8.5 shows a spreadsheet of the GG1111 study.

Following this, inquisitive shop tours were conducted for each of the assemblies/subassemblies for the number "one" ranking product type. This study's analysis of "As-Is" processes served as the baseline for determining where process improvements should be made. The improvements eventually were designed into the "To-Be" factory. Hidden production shortcomings and bottlenecks were found through open dialogues with involved operators.

EXAMPLE OF PROCESS ANALYSIS LISTING

LEGEND: E - EFFICIENCY
LT - LEAD TIME
S - STANDARD IN HRS/1000
Y - YEILD IN %

COLOR CODE: Green - Value Added Operation
Yellow - Inspection Operation
Red - Repair Operation
Pink - Alternate Operation
Blue - Setup, Handling, Cleaning Up

	OP #	OP (AS-IS) DESCRIPTION	E %	LT D:H:M	XX01		XX02		REMARKS
					S	Y	S	Y	
Blue	002F	PROCESS TRAVELER	100	N/A	10.0	100	10.0	100	
Blue	003F	DATA SHEET	100	N/A	15.0	100	15.0	100	
Blue	010A	PREPARE CASE	95	N/A	40.0	95	40.0	99	
Green	035A	WELD CASE	85	N/A	90.0	99	90.0	95	

Figure 8.4. Process Analysis By Gyro Type

AS-IS MANUFACTURING BASELINE: PROCESS ANALYSIS OF GG1111

FINAL ASSEMBLY ONLY

DESCRIPTION	GYRO TYPE	XX01	%	XX02	%
A)TOTAL OPERATIONS LISTED	NUMBER TIME	150 18133	100% 100%	150 18366	100% 100%
B)ALTERNATE OPERATIONS (% OF TOTAL OPS)	NUMBER TIME	11 2133	7% 12%	11 2065	7% 11%
C)REPAIR OPERATIONS (% OF TOTAL OPS)	NUMBER TIME	55 8795	37% 49%	55 8795	37% 48%
D)VALUE ADDED OPERATIONS (% OF TOTAL OPS)	NUMBER TIME	26 2223	17% 12%	26 2870	17% 16%
E)NON-VALUE ADDED OPERATIONS (GROUPS G+H)	NUMBER TIME	58 5131	39% 28%	58 4636	39% 25%
F)ACTIVE OPERATIONS	NUMBER TIME	84 7354	100% 100%	84 7506	100% 100%
G)INSPECTION OPERATION	NUMBER TIME	34 3724	40% 51%	34 3243	40% 43%
H)SETUP,HDLG, CLEANING,ETC OPERATIONS	NUMBER TIME	24 1407	29% 19%	24 1393	29% 19%
I)VALUE ADDED OPERATIONS	NUMBER TIME	26 2223	31% 38%	26 2870	31% 38%

Figure 8.5. Process Analysis for the GG1111

This became one of the most important working documents for the design team. The write-up was structured so as to describe not only the current operation (step-by-step) but also to show ways to improve it. This last section was written only after carefully studying and weighing the various improvement options related to modern manufacturing technologies and techniques, handling, and product testing and inspection. Each of the detailed write-ups was reviewed by line and staff personnel for validation and practical application as well as to create a sense of ownership among the users.

Another study, which was a spinoff of the shop tours, was directed toward studying the material flow (see Figure 8.6). The results of these studies surpassed initial expectations, and required that the project teams pay special attention to efficiently grouping work cells, simplifying and enhancing material handling, and considering real time computer controls for tracking parts through work centers and assembly areas.

At this point, the project team had comprehensive information and adequate details to develop the "To-Be" factory specifications (see Appendix A).

PRELIMINARY DESIGN

With the requirements well documented and supported by actual data, the next step was to develop the manufacturing concept diagram for the individual work areas. Relationships among the work centers, their controls and material flows, and interfaces to other areas within the Stinson/Ridgway plant are shown in Figure 8.7.

The manufacturing concept diagram, designed as a functional flow diagram for all operational functions within one product area, became the first generic factory layout of the new "To-Be" factory. The design diagram and the factory specifications next were reviewed and approved by management along with line and staff personnel before it finally was used in the preliminary and final design phase of the project.

Following a well thought out project methodology during this phase of the program proved to be not only efficient but also vital to project success and quality. The methodology adhered to throughout the entire program is summarized in Figure 8.8.

Following the plan, the initially developed kites were marked up to find the similarities among subassemblies in the various product families along with their grouping. The result was a listing of subassemblies which were either standard or optional for the "To-Be" factory. Additionally, a comprehensive computer spread sheet, using group technology (see Section 7), was developed for all product families within a product group in order to show if a sequential process flow could be developed out of the multitude of flows and thereby lead to the design of a single assembly line or work center. Such a design would be capable of processing all of the product types in one assembly line set up without detouring material or creating delays and/or inefficiencies. Figure 8.9 depicts an example of the computer spread sheet.

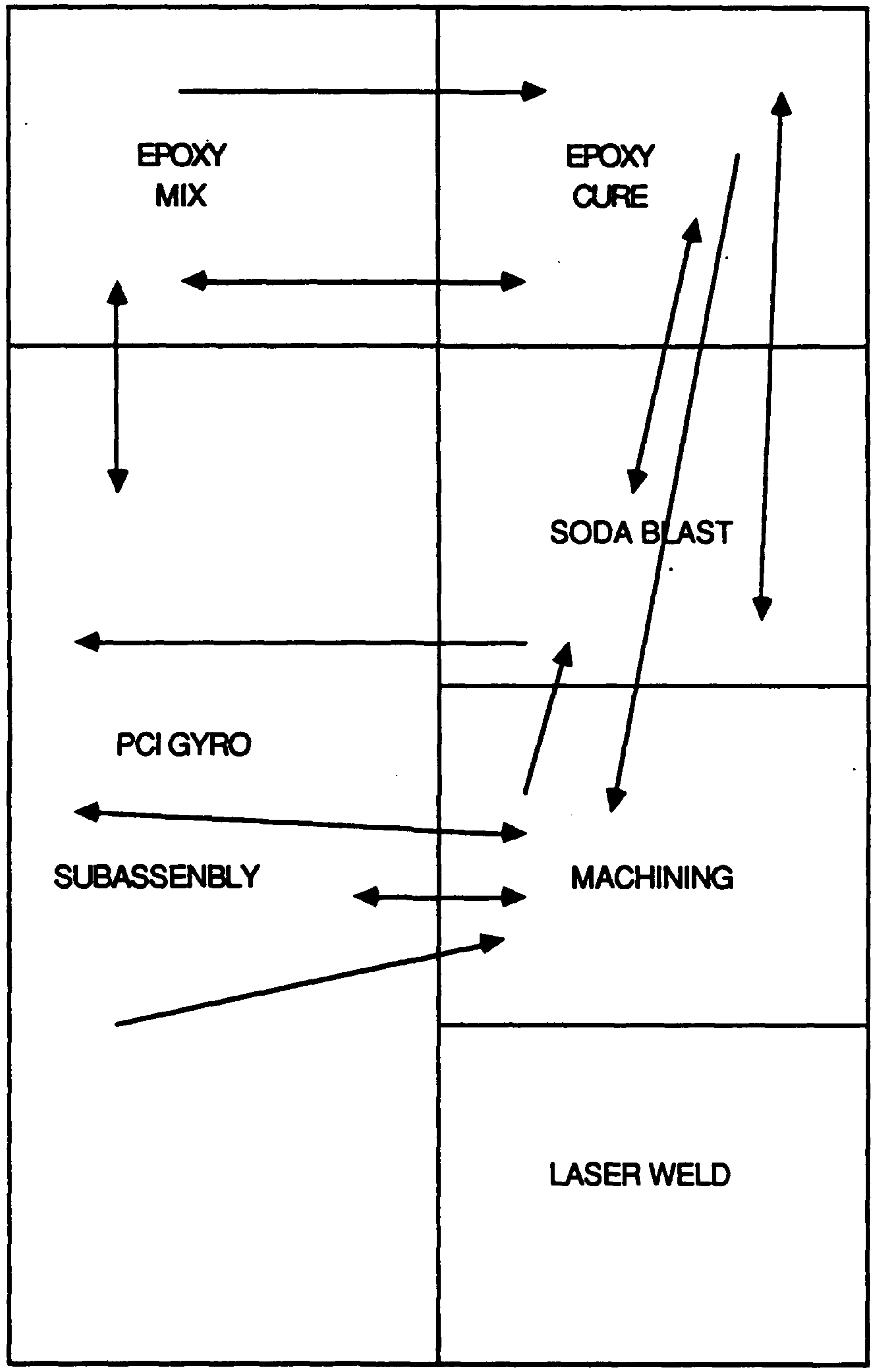
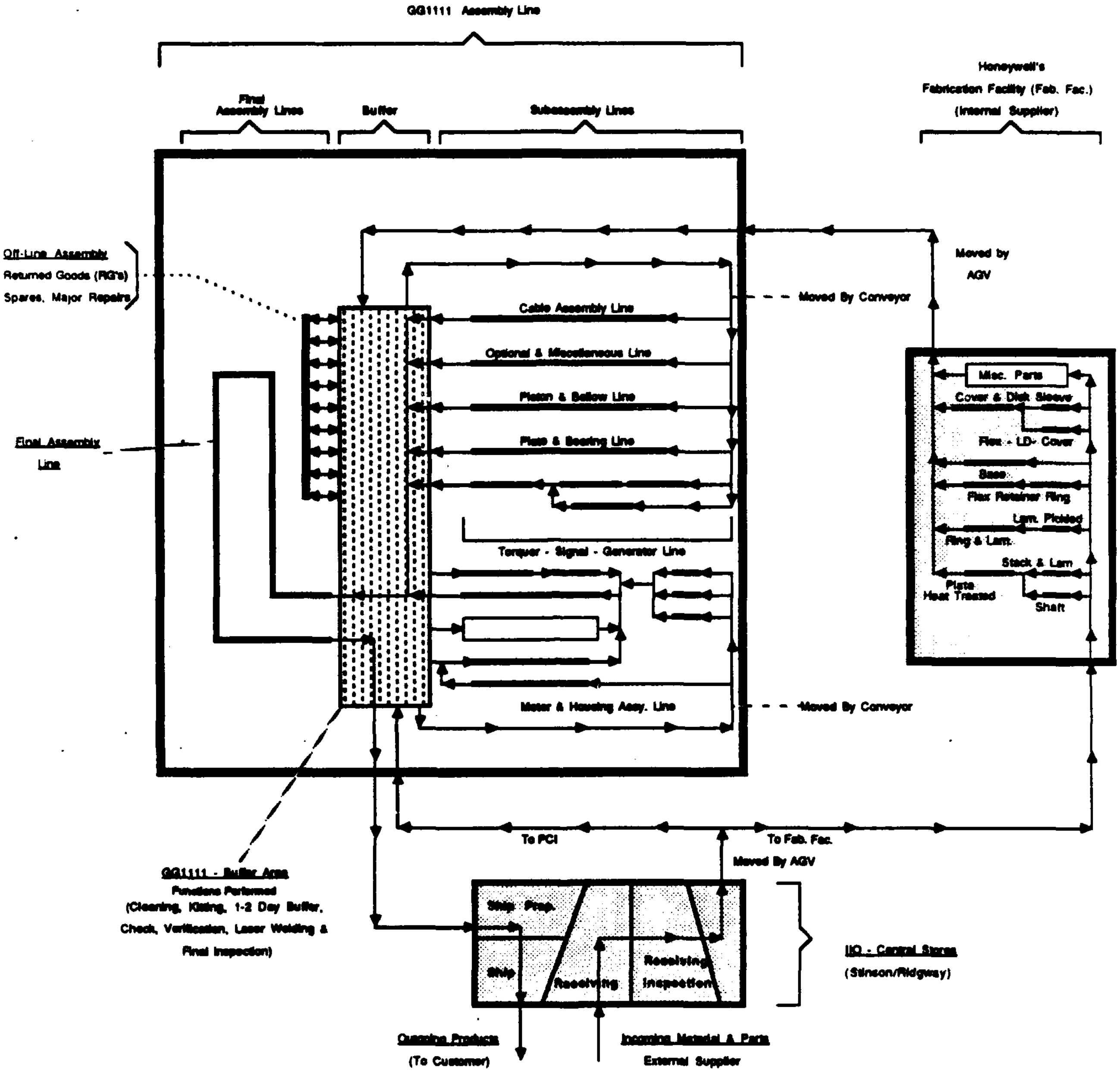


Figure 8.6. "As-Is" Material Flow Among Workstations and Work Cells

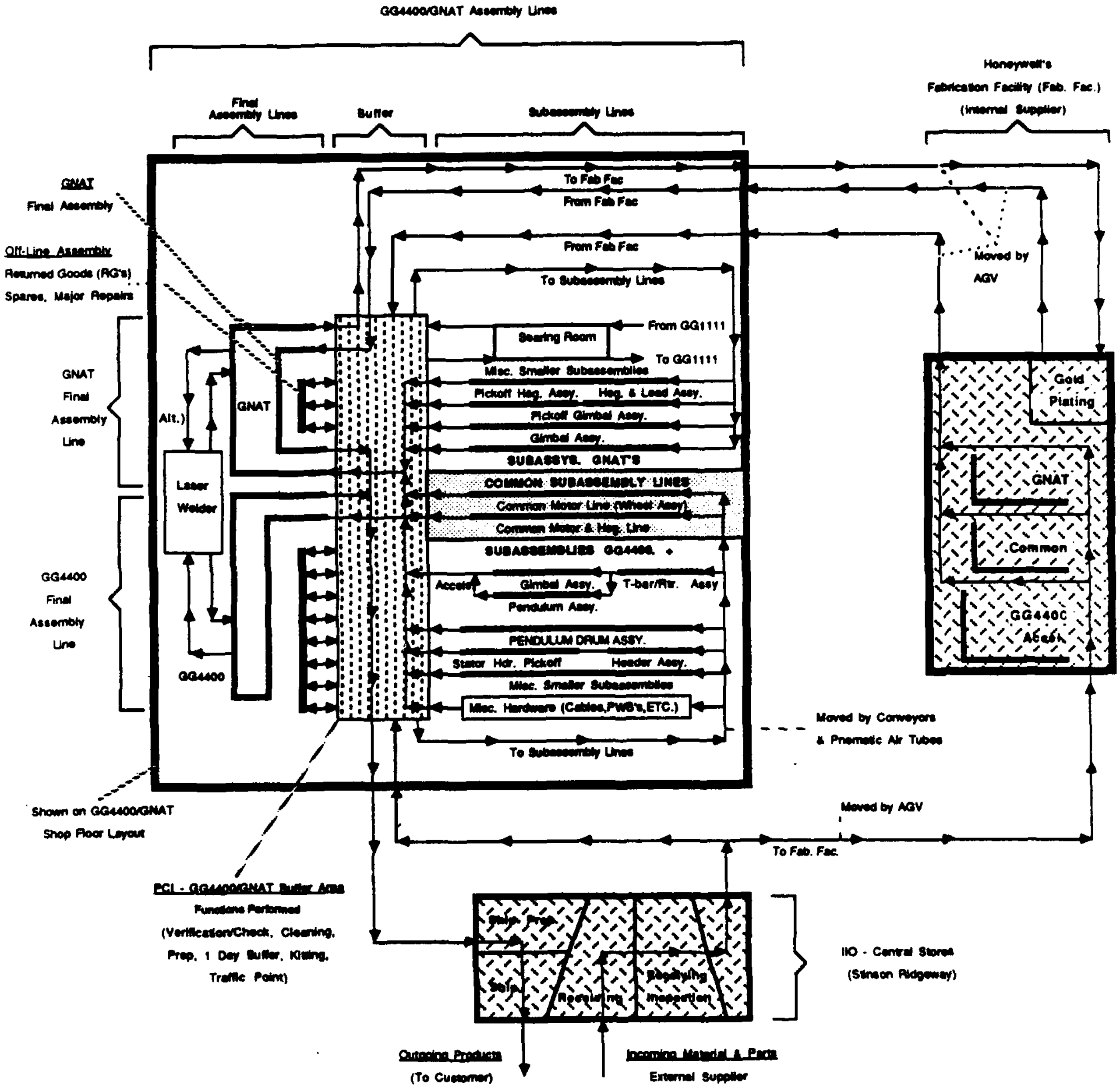


Legend: - Boxes Indicate Functional areas
- Lines with Arrows Indicate Material Flow
- Bold lines in assembly areas indicate entire Sub.or Final Assembly Lines (Not Workstations)

Shaded Areas:
- Material/Parts Supply Areas
- GG1111 - Buffer Area

(Note: All Workcenter Internal Handling is performed Via Conveyors & Pneumatic Tube Systems)

Figure 8.7. Manufacturing Concept



Legend:
- Boxes indicate Functional areas
- Lines with Arrows indicate Material Flow
- Bold lines in Assembly areas indicate entire Sub.or Final Assembly Lines (Not Workstations)

Shaded Areas:
- Material/Parts Supply Areas
- Common GG4400/GNAT Buffer Area
- Common Subassembly Areas

(Note: All Workcenter - Internal Handling is performed Via Conveyors & Pneumatic Tube Systems)

Figure 8.7. Manufacturing Concept (Continued)

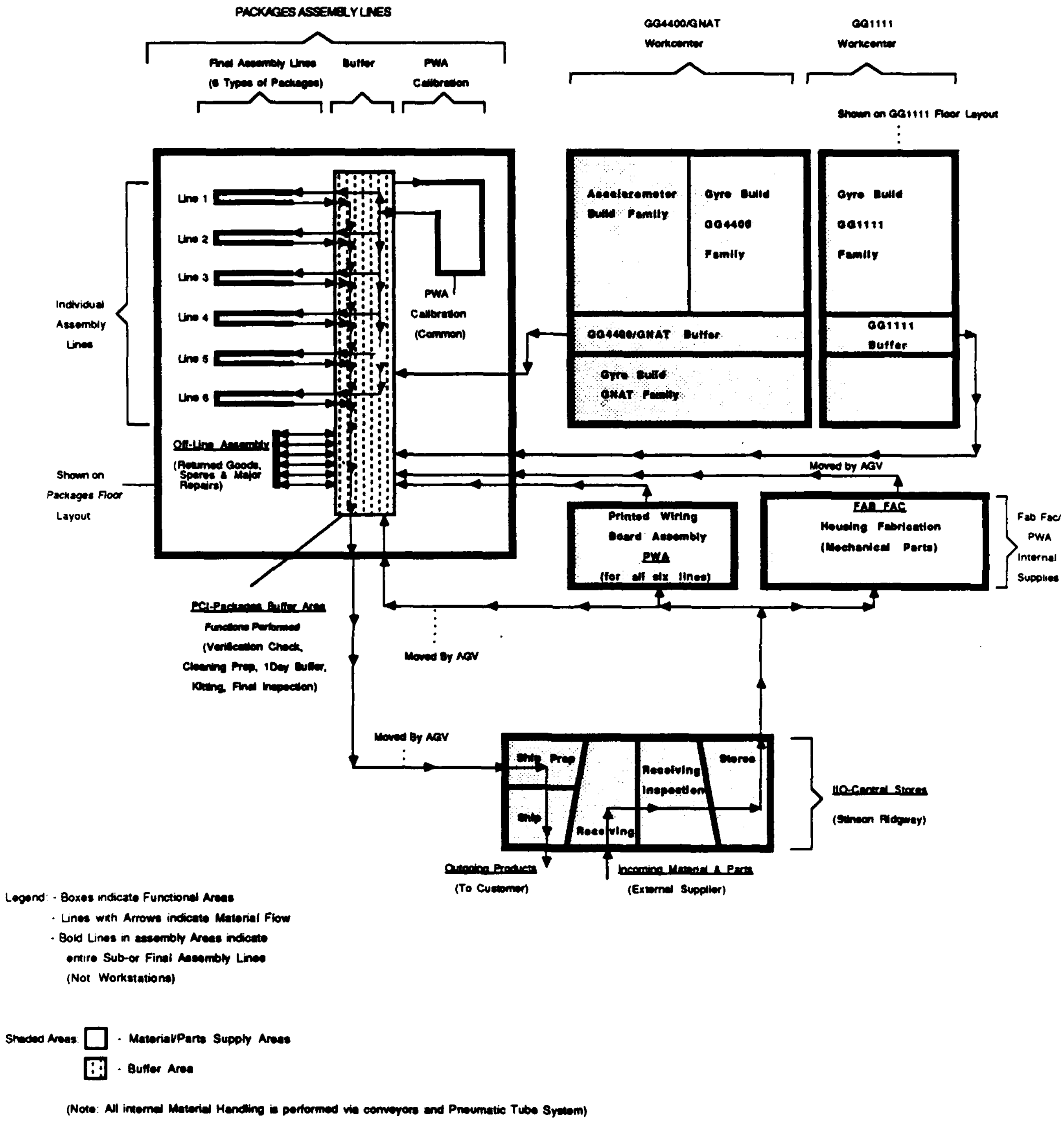


Figure 8.7. Manufacturing Concept (Continued)

PHASE II METHODOLOGY AND PROJECT ACTIVITIES

1. Prepare detailed project plan.
2. Set up project guidelines, philosophies, objectives, goals, boundaries.
3. Set up project office, organize staff.
4. Official project kick-off, mgt & staff.
5. Institute controls, decision makers.
6. Sell Tech Mod to every mgt. & staff member and shop personnel & union.
7. Team 0- Familiarize with product, mfg. system.
8. Team - Study & analyze processes
   - Develop BOM - Kites (breakdowns).
   - Study processes for improvements
   - Group-technology (GT), similarities
   - Shop tour & improvements opportunities
   - Revise "As-Is" processes
   - Develop "To-Be" processes and new system
   - Estimate "To-Be" standards
9. Develop preliminary factory design.
10. Simulate preliminary design.
11. Review and devise on alternative.
12. Refine processes, specs., etc. for final design.
13. Develop list of required tooling and equipment.
14. Develop specifications for tooling and equipment.
15. Request quotations/prices for tooling and equipment.
16. Revise and finalize master building plan
17. Finalize final design
   - Factory layout
   - Processes
   - Standards
   - Manufacturing concept
   - Tooling and equipment, etc.
18. Follow project plan and SOW from GD for details.

Figure 8.8. Project Methodology

	A	B	C	D	E	F
1	OP #	DESCRIPTION	AJI	AKI	LCI	GGXXXXAA01
2						
3						
4	001F	HONEYWELL				
5		PROPRIETARY				
6	002F	DATA	X	X	X	X
7	003F		X	X	X	X
8		HONEYWELL			X/004F	
9		PROPRIETARY				
10	004F	DATA	X			X
11	010A					
12		HONEYWELL				
13	015A	PROPRIETARY			13,20	
14		DATA				
15	015M					
16	020A	HONEYWELL	X	X	X	X
17		PROPRIETARY				
18		DATA				
19	020M					
20	030A	HONEYWELL	X	X	X	X
21		PROPRIETARY				
22	030M	DATA				
23	030B		X	X	X	X
24	030C	HONEYWELL	X	X		
25	032A	PROPRIETARY	X	X	X	X
26	035A	DATA	03-05,07,10-16,18,20,21		ALL EXCEPT 10,13,20	X
27						
28	035B	HONEYWELL	03-05,07,10-16,18,20,21		ALL EXCEPT 10,13,20	
29		PROPRIETARY				
30	035C	DATA	03-05,07,10-16,18,20,21			
31	036A		03-05,07,10-16,18,20,21		ALL EXCEPT 10,13,20	X
32		HONEYWELL				
33	040A	PROPRIETARY	X	X	X	X
34		DATA		X/041A		
35						
36		HONEYWELL				
37	041A	PROPRIETARY	X		X	
38	042A	DATA	X	X	X	X
39	043A					
40	044A	HONEYWELL				
41	045A	PROPRIETARY	X	X	X	X
42	047A	DATA	X	X	X	X
43	049A		X	X	X	X
44	050A	HONEYWELL	X	X	X	X
45		PROPRIETARY				
46		DATA				
47	050M					
48	055A	HONEYWELL	X	X	X	X
49	060A	PROPRIETARY	X	X	X	X
50	060S	DATA				
51	065A		X	X	X	X
52	070A	HONEYWELL	X	X	X	X
53		PROPRIETARY				
54	070M	DATA				
55	075A		X	X	X	X
56		HONEYWELL				
57	075M	PROPRIETARY				
58	085A	DATA	X	X	X	X
59	089M					
60	090A	HONEYWELL				
61	090M	PROPRIETARY				
62	099A	DATA	X	X	X	
63	099S					
64	100A	HONEYWELL	X	X	X	X
65	100S	PROPRIETARY				
66	110A	DATA	X	X	X	X

Figure 8.9. Group Technology Operations Breakdown (GG1111)

Another computer spread sheet was developed for the next most complex subassembly in the case of the GG1111 gimbal subassembly. Although this spreadsheet initially was viewed only as a development tool for the preliminary and final design, it explicitly demonstrated that it would be impossible to operate and control the the "To-Be" processes with the currently applied control mechanisms and tools. Consequently, this spread sheet alerted the design team to look for computer controls as a means for controlling the operation of the "To-Be" factory.

With the group technology spread sheet and the improvement opportunities identified, the preliminary process and technology improvements were developed and recorded on the charts which originally had been used to distinguish between value-added and non-value-added operations (see Figure 8.10). This iteration removed redundant, alternate, and repair operations; the remaining operations were enhanced according to the "Improvement Opportunities" document. As a result, the marked up charts showed drastic reductions in process activities.

Following this first step, each of the labor standards for the remaining operations was estimated based on process improvements exclusively. The results were charted displaying the very ceiling of possible process and standard improvements. These charted results may be considered the first design of the "To-Be" process.

The next step was to roughly outline the required equipment and tooling as well as an estimate of the related capital expenditures (see Figure 8.11). A preliminary cost comparison was put together using actual cost rates and acceptable efficiency, scrap, and rework levels to determine if the improvements made so far would yield a satisfactory level of return or if the design team would have to go back to the drawing board one more time to make changes. Fortunately, the first few comparisons made primarily with A-parts (i.e., major parts) surpassed team expectations. Consequently, the design team stopped at this level of improvements. Further cuts would have meant further automation and product design changes. As it was proven later, the original savings predictions were right on target whereas expenditures were slightly undervalued mainly due to the influence of high dollar items like ATE's. After publishing the results to management and staff, the design team started developing the final "To-Be" processes based on the preliminary findings (see Figure 8.12).

FINAL DESIGN

The design team chose to start with the details of the final design first and then to create the factory out of the individual details. This approach was the most feasible alternative at hand since all of the operations are complex and are not very transparent even to people who are familiar with production. Using the gyro breakdown chart (see Figure 8.13) and the individual kites, the next step was to make the make/buy decision and determine which of the subassemblies and parts could best be produced in the Fabrication Facility (Fab Fac) and PCI.

CC - FAMILY

PROJECT 51/52

PROCESS FLOW/SIMILARITIES FOR GG1111 - GYRO FAMILIES

LEGEND: E = EFFICIENCY
LT = LEADTIME
S = STANDARD IN HRS/M
Y = YIELD IN %

SHEET _1__ OF ___

OP #	OP DESCRIPTION	E %	LT D:H:M	CC S	CC Y	CC S	CC Y	CC S	CC Y	CC S	CC Y	CC S	CC Y	REMARKS
XXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX			XXXXX		CRT'S								
XXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX			XXXXX		CRT'S								
XXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX			XXXXX		DONE IN BUFFER/KITTING AREA								
XXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	1		XXXXX		DONE IN BUFFER/KITTING AREA								
020A	PREPARE CAGE FOR WELD	2		86.0		AS IS		(MOVE TO LINE)						
030A	WELD HEADER ASSY TO CAGE(LASER)	3		50.0		AS IS		(MOVE TO LINE)						
XXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	4		XXXXX		OPTONAL OP DELETED COMPLETELY								
032A	LEAK CHECK HEADER TO CASE	5		17.0		AS IS		(MOVE TO LINE)						
XXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	6		XXXXX		M-OP ELIMINATE								
035A	WELD GND TERM #2 (LASER CO2)	7		0.0		NOT FOR CCIP (OPTIONAL)								
XXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	8		XXXXX		OPTIONAL OP DELETED TOTALLY								
036A	SOLDER GROUND PIN	9		0.0		NOT FOR CCID (OPTIONAL)								
XXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	10		XXXXX		DONE IN BUFFER AREA								
XXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	11		XXXXX		MODIFY COVER & MOVE TO REC. INSP. POINT								
XXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	12		XXXXX		MOVE TO BUFFER AREA - KITTING ACTIVITY								
XXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	13		XXXXX		MOVED TO APPROPRIATE SPOT &DONE W/AUTOM. TESTER								
047A	ASM BEARING TIN TERMINALS	14		126.8										
XXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	15		XXXXX		BONDING OF BAG'S ELIMINATED/NO CUTTING								
050A	CLEAN PARTS KIT	16		65.5		MOVE OP TO BUFFER AREA INCREASE AUTOMATION								
XXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	17		XXXXX		TIGHTEN REC CONTROL MEASURES & ELIMINATE								
060A	CHECK END PLAY	18		159.0		INCREASE TECHNOLOGY TO MEASURE(EQUIPMENT)								
065A	CHECK PADDLE GAP & BELLOWS	19		46.0		& COMBINE 060A & 065A EST. 40.0 H/P FOR 0								
XXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	20		XXXXX		USE AUTOM. BALL SELECTER LAZER BALL IS PUSHED								
XXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	21		XXXXX		ELIMINATED THRU STRICT CLEAN ROOM MEASURES OP 050A								

NOTE: XXXX - (Operations being removed are marked out)

Figure 8.10. Transition to the "To-Be" Process

ASSEMBLY: GIMBAL S/A PRODUCT TYPE: GG1111-LC10

PRELIMINARY COST COMPARISON FOR LC10 GYRO-F/A

DESCRIPTION	"AS-IS"	"TO-BE"	REMARK
Labor Standard (HRS/M)	3455.50	807.90	
Investment $		$529,000 ROM Estimate	
Savings/Year		Pessimistic 14562 hour/year Optimistic 31771 hour/year	
Feasibility	Present Set-up (Proven)	- Modernization - Proven Technology - 1 to 2 year implementation	

EQUIPMENT ESTIMATES FOR GIMBAL (6/11/86)

OP.020A	INSTALL MOTOR TO HSG. & TORQUE	PT #10042638-TAB	$31,000
OP.025A	INSPECTION		7,000
OP.035A	ASSEMBLE GIMBAL COVER		9,500
OP.040A	BONDING & CURINGS/VS WELDING		1,500
OP.041A	LEAK CHECK (LEAVE "AS-IS"; Set up improvements)		1,500
OP.042A	FILL & SEAL		15,000
OP.046A	START MOTOR RUN IN		120,000
OP.060A	LOW TEMPS START TEST		150,000
OP.087A	CEMENT INSERT - COMBINED OP WITH 085/087 & 88		10,000
OP.090A	MACHINE GIMBAL - FITTING PINS (Addition to special machine above)		6,000
OP.094A	MAKE GRIT BLASE MOLD (Upgrade workstation only)		3,000
OP.128A	CEMENT TERMINALS (FIXTURE ONLY, USE EQUIP. AVAILABLE)		1,000
OP.130A	ASM COIL CUP (Precision dispenser)		3,500
OP.135A	TRIM TERMINAL LENGTH (Special power cutting & stripping tool)		9,000
OP.139A	DIP TIN TERMINALS (vapor phase soldering equipment, miniature)		6,000
OP.141A	SOLDER COIL CUP LEAD WIRES (Advanced soldering tool)		5,000
OP.165A	ROTATIONAL BALANCE (Small tabletop computerized balancer)		35,000
OP.166A	CEMENT COMPENSATOR SLUGS (Fixture/device to bond slugs to gimbal)		1,500
OP.191A	TEMPERATURE CYCLE (temp. cycling oven upgrade with computer)		60,000
OP.200A	DIELECTRIC & CONTINUITY CHECK (Computerized/autom tester)		18,000
OP.210A	LEAK CHECK (Leak check equipment)		15,000
OP.230S	FINAL INSPECTION (Computerized test set up)		9,000
	TOTAL ESTIMATE "TO-BE" CAPITAL (GIMBAL LINE)		$516,500

Figure 8.11. Preliminary Cost Comparison/Capital Expenditure (Gimbal)

CC - FAMILY

PROJECT 51/52

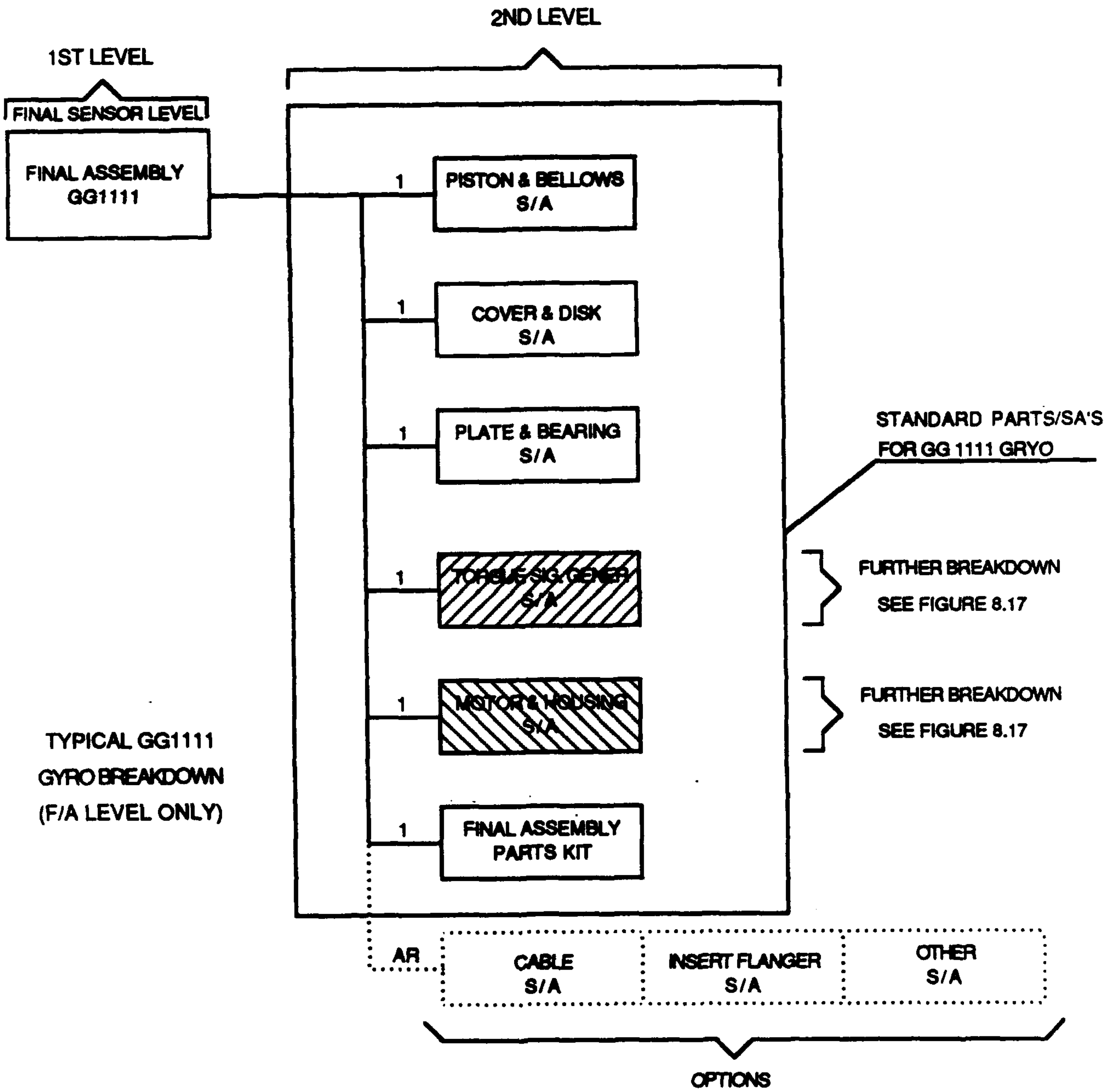
PROCESS FLOW/SIMILARITIES FOR GG1111 - GYRO FAMILIES

LEGEND: E = EFFICIENCY
LT = LEADTIME
S = STANDARD IN HRS/M
Y = YIELD IN %

SHEET 5 OF 5

OP #	OP DESCRIPTION	E %	LT D:H:M	CC S	CC Y	CC S	CC Y	CC S	CC Y	CC S	CC Y	CC S	CC Y	REMARKS
715M	ADJ. LEADWIRE			50.0										
730M	REPLACE PIN LEADS			400.0										
740M	CLEAN UP PINS FOR SOLDERING			250.0										
748M	REPAIR SCRATCHES ON CONNECTOR			80.0										
750M	REMOVE POTTING			500.0										
755M	REMOVE CABLE AND COMP.			100.0										
760M	REMOVE (1) COMP. (RES.OR CAP) & REPLACE			75.0										

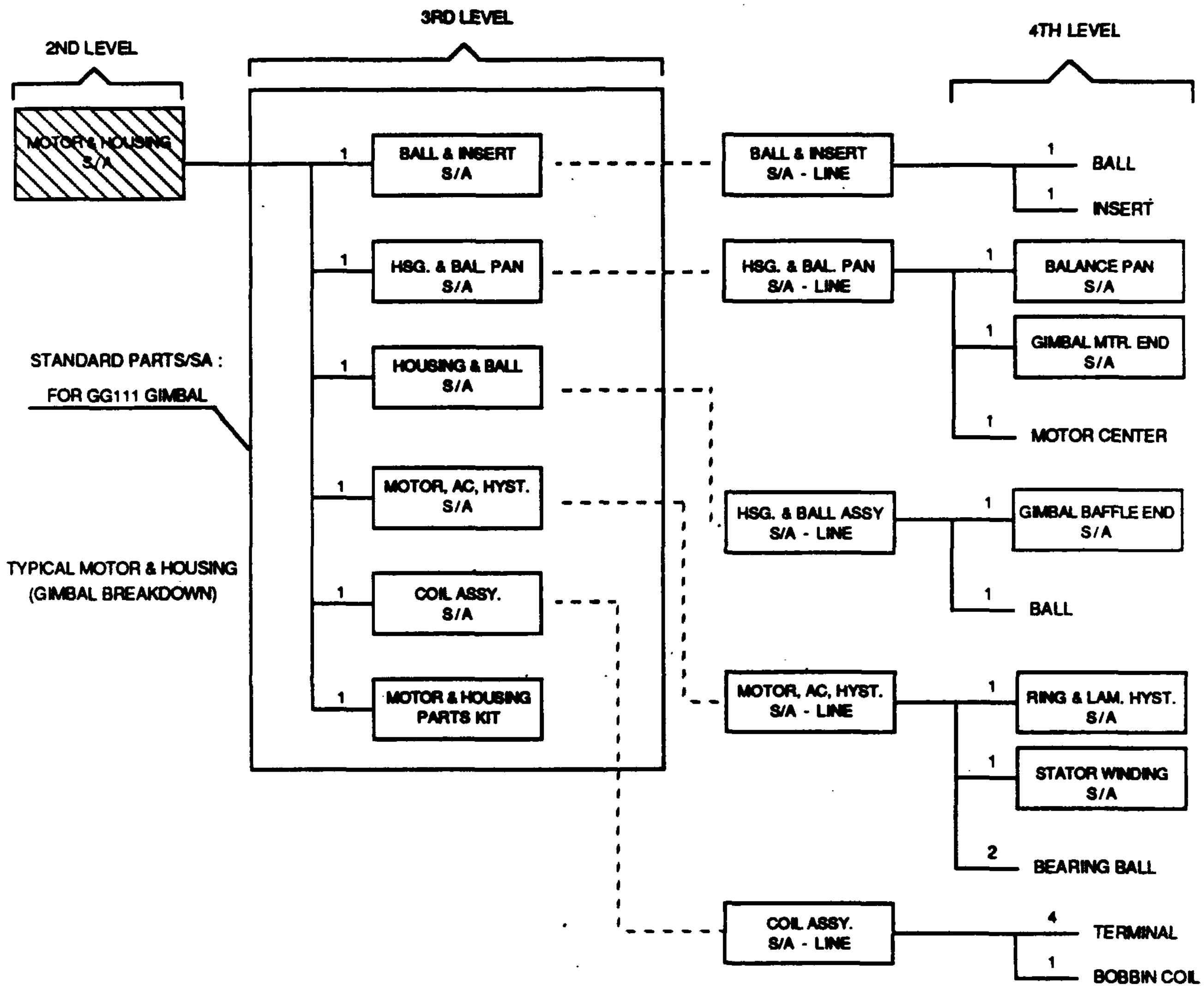
Figure 8.12. "To-Be" Process Development



NOTE: 1st Level - Final Level Of Product Build
2nd Level - Final Subassembly Level Prior To Final Assembly Of Gyro

LEGEND: AR - As Required
S/A - Subassembly

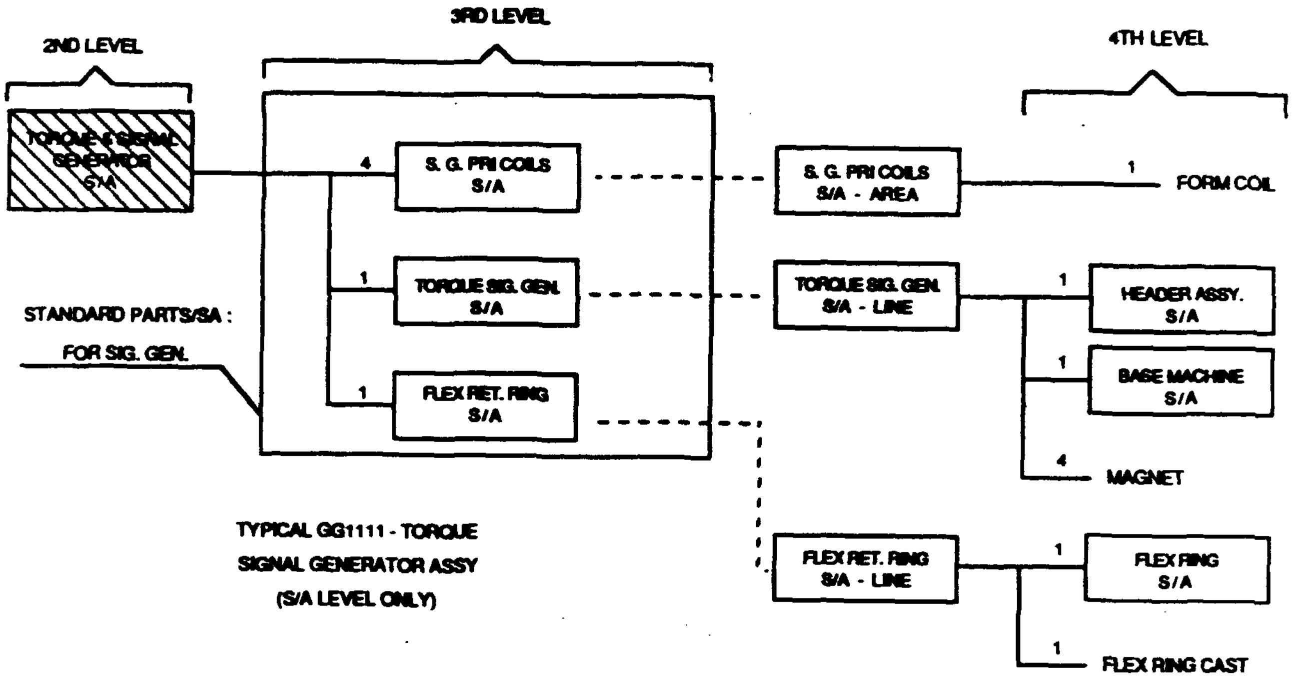
Figure 8.13. Sensor Breakdown Chart (GG1111)



NOTE: Levels Indicate Subassembly Levels

LEGEND: AR - As Required
S/A - Subassembly

Figure 8.13. Continued



<u>NOTE:</u> Levels Indicate Subassembly Levels

<u>LEGEND:</u> AR - As Required
S/A - Subassembly

Figure 8.13. Continued

Make/buy decisions were based mainly on requirements for not duplicating equipment and not sending parts or subassemblies back and forth to Fab Fac for machining after the assembly process had already started. This decision led to some highly specialized, automated, and dedicated equipment in PCI which was integrated in the "To-Be" factory design in order to replace the current machining in Fab Fac. It also led to the decision to farm out entire subassemblies and parts to Fab Fac, thus eliminating delays and idle times in both departments. Other parts and subassemblies were subcontracted to outside vendors to eliminate delays/idle times as well as to cut high internal costs in some cases.

Following the make/buy decision for parts and subassemblies, the next step was to develop the detailed "To-Be" processes. The previously listed charts and data were used in combination with comprehensive detail layouts and summaries explaining the operations and processes. The detail layouts delineated action steps and process peculiarities as well as noting equipment and tooling which could be used. Figure 8.14 depicts an example of these hand written drafts.

After completing the drafts, a preliminary system layout of each individual assembly and subassembly was developed for displaying the logistics of work cells and assembly lines. Tooling and equipment needs also were included. The system layout further displayed the complexity of material flow along with the steps and processes through which the part/assembly would be processed. Figure 8.15 shows examples of these system layouts for a selected number of assemblies.

Labor standards and equipment process times then were added to each of the operations by the Industrial Engineering department using the motion study system, "MOST". At this point, all data was transferred to a specially prepared computer spreadsheet for computing manpower requirements and lead times; the spreadsheets also would be used for line balancing at a later time. Generic equipment and tooling were selected, coded, and entered. However, these resources were not yet specified to final detail. Wherever existing equipment or tooling was used in the "To-Be" processes, it was entered under the current numbering and coding system. Figure 8.16 depicts a typical computer printout with "To-Be" processes representing assemblies and subassemblies from all product groups.

Concurrent with creating the individual "To-Be" processes, Honeywell's Tool Design department conceptualized the advanced tooling and/or devices represented on the computer spreadsheets. Figures 8.17 and 10.5 through 10.10 show typical tooling concepts (see Section 10). The tooling costs for the CBA study were taken directly from these tooling concepts after the tool designer had estimated design and build times for the individual devices. Equipment specifications were prepared based on the initial selections and generic descriptions previously made.

TECH MOD S1/S2

PROPOSED "TO BE" PROCESS/METHODS

PT: FINAL ASSEMBLY GG1111 (ALL VERSIONS)

GG1111 GYRO

					ROM ESTIMATES							
#	M E	OP NR	STEP	OPERATION DESCRIPTION DETAIL	Line Eff. %	Est. Std. H/M	Equip Process Time (hours)	E Positions	Elapsed Time TOTAL (Work Station Time)	TOOLING CODE	EQUIPMENT CODE	REMARKS
1		GENERAL		NOTE: THE SUPPLY OF PARTS TO THE FINAL ASSEMBLY		/	/					INFO ONLY
2				LINE IS PRECISELY TIMED TO THE LINE CYCLE								INFO ONLY
3				TIME BY COMPUTER AND CONTROLLED BY THE								INFO ONLY
4				BUFFER AREA:								INFO ONLY
5				THE FINAL ASSEMBLY ACTIVITIES ARE DIVIDED								INFO ONLY
6				INTO 3 MAJOR SECTIONS:								INFO ONLY
7				-SECTION 1: WELDING OF HEADER TO CASE								INFO ONLY
8				-SECTION 2: FINAL ASSEMBLY-STANDARD LINE								INFO ONLY
9				-SECTION 3: FINAL ASSEMBLY-PECULIAR TESTS								INFO ONLY
				(EXCESSIVE OPERATION TIMES)								
10		GENERAL		PARTS & ASSEMBLIES ARE KITTED ACCCORDING		/	/					INFO ONLY
11				TO ASSEMBLY REQUIREMENTS AT THESE								INFO ONLY
12				INDIVIDUAL (3) SECTIONS ALL TO THE 'BOM'								INFO ONLY
13				-FOR SECTION 1: CASE & HEAHER ASSY.								INFO ONLY
14				-FOR SECTION 2: ALL STANDARD PARTS AND								INFO ONLY
15				ASSEMBLIES ALL TO 'BOM', EXCLUDING								INFO ONLY
16				OPTIONAL PARTS AND ASSEMBLIES								INFO ONLY
17				-FOR SECTION 3: ALL BURN-INS ETC. FOR FINAL								INFO ONLY
18				ASSEMBLIES-STANDARD GYRO-ASSEMBLIES								INFO ONLY
19				ENTER FROM THE STANDARD LINE								INFO ONLY
20		PCI		SECTION 1: WELDING HEADER TO CASE		/	/					
21				OPTIONAL WELDING OF GROUND TERMINAL								
				(SHEET 1-4)								
22		BUFFER		-RECEIVE GYRO CASE FROM FAB. FAC.		/	/					
23												
24												
25												

Figure 8.14. Preliminary "To-Be" Process (GG1111 Final Assembly)

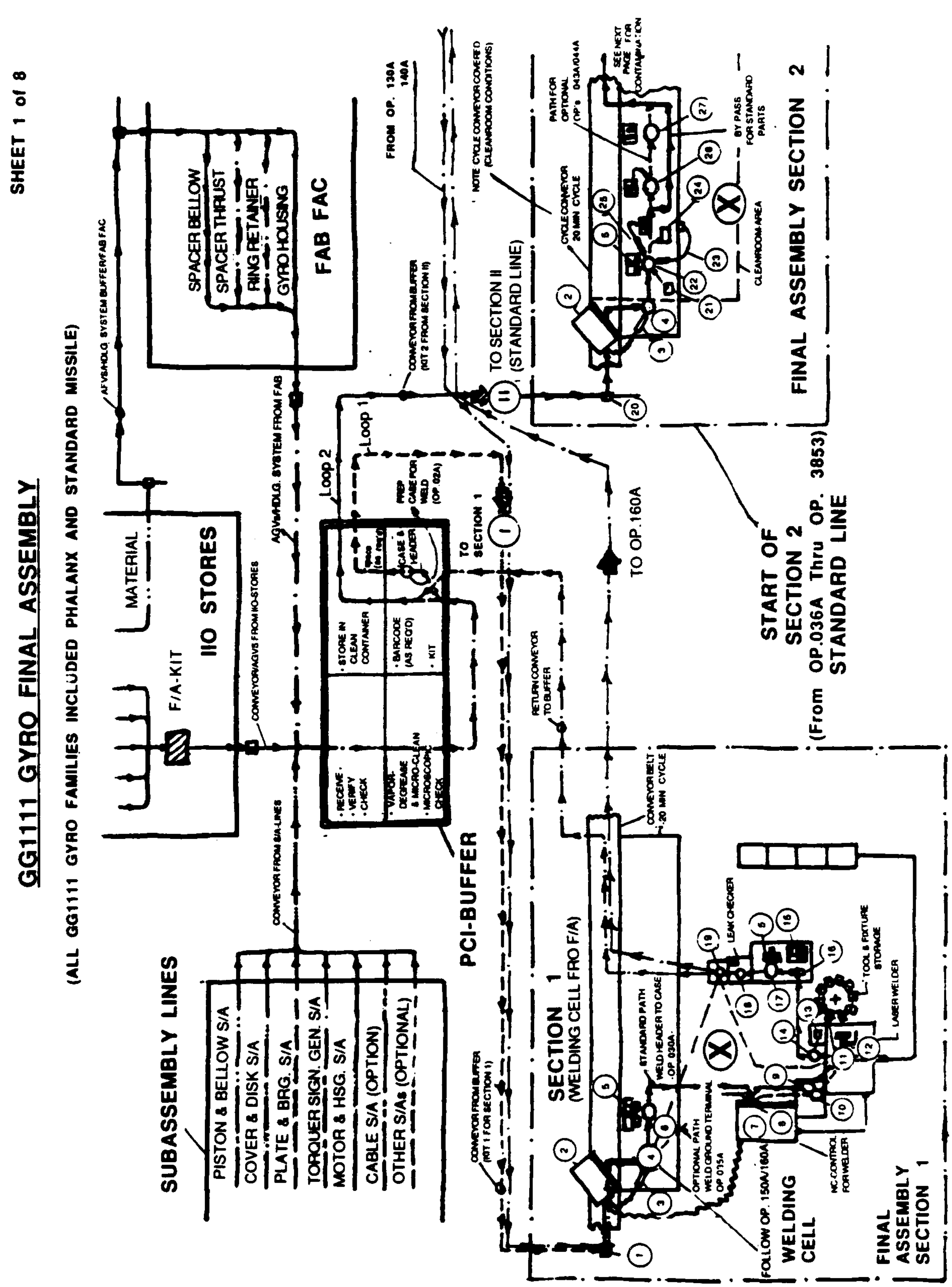


Figure 8.15. Preliminary "To-Be" System Layout (GG1111 Final Assembly)

SHEET 2 of 8

GG1111 GYRO FINAL ASSEMBLY

(ALL GG1111 GYRO FAMILIES INCLUDED PHALANX AND STANDARD MISSILE)

SECTION 2

STANDARDLINE (OP.036A THRU OP.3855)

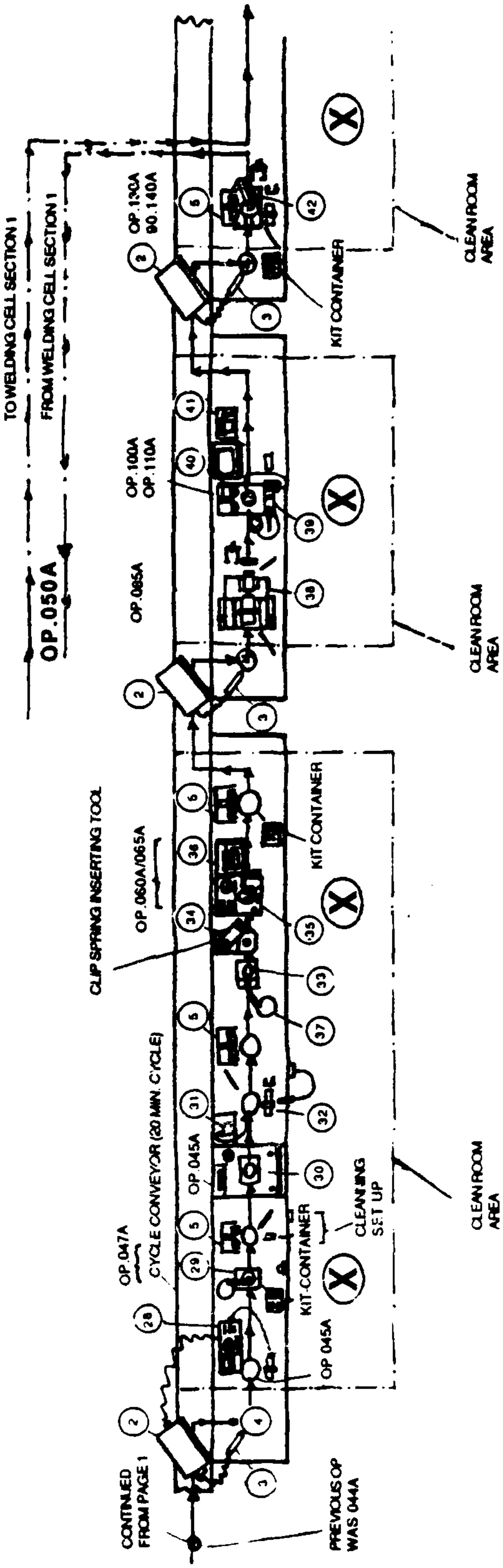


Figure 8.15. Continued

TECH MOD 51/52: TO-BE PROCESS - GNAT GYRO
FINAL ASSEMBLY GNAT (ALL VERSIONS) (GNAT FA)

CYCLE TIME (CT) = 407 M/HRS

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ISSUE : 5
DATE: 6/11/87

#	OP #	OPERATION DESCRIPTION DETAIL	A VAC ABST %	B LINE EFF %	C DOWN TIME %	D STD HRS (H/M)	E ADJ STD HRS (H/M)	F MANPOWER BY OP	G MANPOWER W/VAC & ABST	H PROCESS TIME W/O LAB. (HRS)	I # OF STAG POINTS	J PROCESS TIME + LABOR (HRS)	K ELAPSED TIME TOTAL (HRS)	TOOLING CODE	EQUIPMENT CODE	REMARKS
INPUT	INPUT	INPUT	INPUT	INPUT	INPUT	INPUT	[(D/B) + (D*C)]	[E/CT]	[(A*E)/CT]+F	INPUT	E/1000 + H*C+ (H/CT/1000)	E/1000 + H(1 + C)	CUM OF J			
1	GENERAL	NOTE: THE NEW TO-BE PROCESS FOR GNAT IS BASED ON					0.00	0.00	0.00		0.00	0.00	0.00			INFO. ONLY
2		THE PRESENT GYRO DESIGN. TECH MOD DOES NOT PROPOSE					0.00	0.00	0.00		0.00	0.00	0.00			
3		DESIGN CHANGES FOR GNAT BUT RECOMMENDS TO					0.00	0.00	0.00		0.00	0.00	0.00			
4		CHANGE OVER FROM GOLD PLATING TO A LESS COSTLY/					0.00	0.00	0.00		0.00	0.00	0.00			
5		TIMELY SURF. FINISH PROCESS (E.G. BLACK ANODIZING)					0.00	0.00	0.00		0.00	0.00	0.00			
6							0.00	0.00	0.00		0.00	0.00	0.00			
7	GENERAL	NOTE: THE SUPPLY OF PARTS TO THE FINAL ASSEMBLY					0.00	0.00	0.00		0.00	0.00	0.00			REPLACE GOLD
8		LINE IS ACCURATELY TIMED TO THE LINE CYCLE OF THE					0.00	0.00	0.00		0.00	0.00	0.00			PLATING THRU
9		GNAT LINE - THE TIMING IS CLOCKED/SEQUENCED THRU					0.00	0.00	0.00		0.00	0.00	0.00			BLACK ANODIZING
10		COMPUTER AND A SHOP FLOOR CONTROL SYSTEM, AND					0.00	0.00	0.00		0.00	0.00	0.00			& DO IN BUFFER
11		IS CONTROLLED BY THE BUFFER AREA.					0.00	0.00	0.00		0.00	0.00	0.00			OF GNAT AREA
12		- ALL OF THE PROCESSES ARE PERFORMED IN THE					0.00	0.00	0.00		0.00	0.00	0.00			
13		PROPOSED TO- BE FINAL ASSEMBLY LINE.					0.00	0.00	0.00		0.00	0.00	0.00			
14							0.00	0.00	0.00		0.00	0.00	0.00			
15	GENERAL	ACCORDING TO BOM, PARTS & SUBASSEMBLIES ARE KITTED					0.00	0.00	0.00		0.00	0.00	0.00			INFO. ONLY
16		IN THE BUFFER AREA FOR THE FINAL ASSEMBLY LINE,					0.00	0.00	0.00		0.00	0.00	0.00			
17		TYPICALLY A KIT CONTAINING THE FOLLOWING:					0.00	0.00	0.00		0.00	0.00	0.00			
18		- PICKOFF GIMBAL, SUBASSEMBLY					0.00	0.00	0.00		0.00	0.00	0.00			
19		- COMPENSATOR ASSEMBLY					0.00	0.00	0.00		0.00	0.00	0.00			
20		- THERMISTOR ASSEMBLY					0.00	0.00	0.00		0.00	0.00	0.00			
21		- PADDLE ASSEMBLY					0.00	0.00	0.00		0.00	0.00	0.00			
22		- OUTER GYRO HOUSING					0.00	0.00	0.00		0.00	0.00	0.00			
23		- FINAL ASSEMBLY PARTS KIT (SEE BOM)					0.00	0.00	0.00		0.00	0.00	0.00			
24		ALL PARTS/SUBASSEMBLIES ENTER THE FINAL ASSEMBLY					0.00	0.00	0.00		0.00	0.00	0.00			
25		LINE AS A COMPLETED KIT.					0.00	0.00	0.00		0.00	0.00	0.00			
26							0.00	0.00	0.00		0.00	0.00	0.00			
27	BUFFER	RECEIVE PARTS FROM FAB FAC AND IO-STORES.					0.00	0.00	0.00		0.00	0.00	0.00		MHE-001-001	
28		- READ IN BARCODE AND COMPUTER VERIFIES PARTS					0.00	0.00	0.00		0.00	0.00	0.00		BAR-999-001	
29		- DIMENSIONALLY CHECK AND VISUALLY CHECK PARTS					0.00	0.00	0.00		0.00	0.00	0.00			
30		- VAPOR DEGREASE AND MICRO CLEAN PARTS AS REQUIRED					0.00	0.00	0.00		0.00	0.00	0.00		ROB-002-001	
31		- MICROSCOPIC CHECK FOR CLEANLINESS					0.00	0.00	0.00		0.00	0.00	0.00		INS-846-001	
32		- BARCODE AS REQUIRED AND QUEUE (FOR KITTING)					0.00	0.00	0.00		0.00	0.00	0.00		BAR-005-001	
33							0.00	0.00	0.00		0.00	0.00	0.00			
34	BUFFER	- LASER SCRIBE OUTER HOUSING					0.00	0.00	0.00		0.00	0.00	0.00		LAS-008-001	
35	015	- PUT IN HOLDING FIXTURE & ALIGN FOR MARKING					0.00	0.00	0.00		0.00	0.00	0.00			
36		- LASER SCRIBE/MARK GYRO MODEL #					0.00	0.00	0.00		0.00	0.00	0.00			
37		- REMOVE FROM HOLDING FIXTURE & CHECK MARKING					0.00	0.00	0.00		0.00	0.00	0.00			
38		- VAPOR DEGREASE & MICRO CLEAN (AS REQUIRED)					0.00	0.00	0.00		0.00	0.00	0.00			
39							0.00	0.00	0.00		0.00	0.00	0.00			
40							0.00	0.00	0.00		0.00	0.00	0.00			

Figure 8.16. Typical Computer Printout of "To-Be" Processes for GNAT Final Assembly

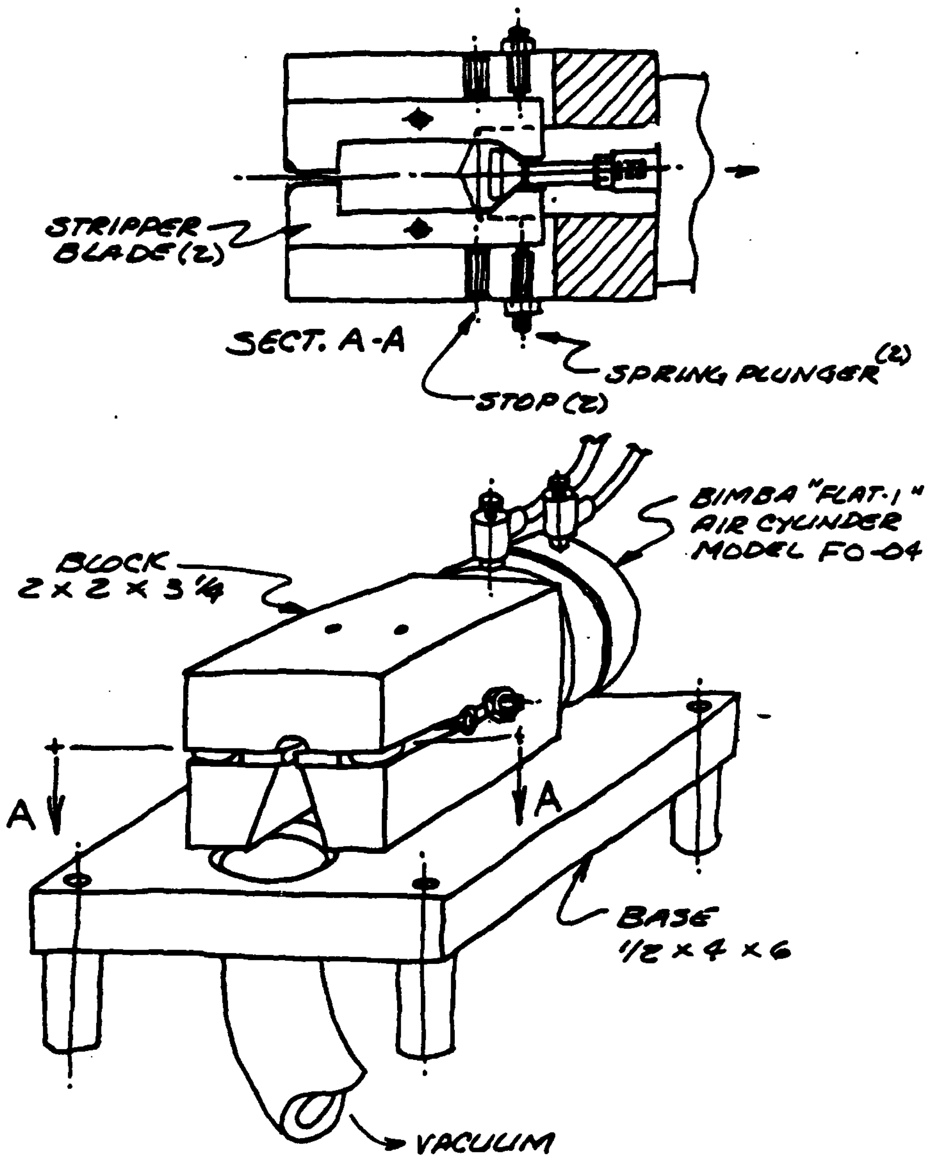


Figure 8.17. Tooling Concepts (Spinmotor Assembly Cell)

The criteria for selecting and specifying the various equipment types is listed below:

- High automation level
- Minimum or zero set-up
- Specialized versus universal equipment
- Table top size wherever possible (i.e., miniaturized equipment)
- High accuracy and repeatability
- High reliability/minimum downtime
- Self diagnostic/minimum maintenance
- Operator friendly/minimum training requirements
- For more complex equipment: activation and/or set-up through barcode
- Flow through system for continuous line flow
- Integratable with computer system
- Meet clean room requirements where necessary
- Reasonable price and equipment availability

Equipment selection and specification was supported through up-to-date technical information and brochures. This background information had been collected as part of the equipment search tasks. Consequently, this literature had been sorted into several dozen groups and coded for easy reference (see Figure 8.18). A typical equipment specification sheet is shown in Figure 8.19. These specifications sheets were used whenever equipment quotations were requested from the various vendors.

As soon as the "To-Be" processes were established and printed, copies were distributed to staff personnel for review and approval. In the meantime, Industrial Engineering started formulating input data for simulating the "To-Be" factory by using the "SIMAN" (and later the "WITNESS") simulation program. The objective of running the "To-Be" data through a simulation program was twofold:

1) It was essential to determine if line balancing was done correctly and did not contain hidden bottlenecks;

2) It was important to see how the complex assembly lines would work together.

EQUIPMENT LISTING

CODING KEY

ADH	ADHESIVE/ADHESIVES EQUIPMENT	LAS	LASER EQUIPMENT
ASE	ASSEMBLY EQUIPMENT	MAC	MACHINE TOOLS
ATE	ATE - STATION	MEE	MEASURING EQUIPMENT
AUT	AUTOMATION/PHILOSOPHIES/CASES	MIT	MISCELLANEOUS TOOLS
BAR	BARCODE SYSTEM	MHE	MATERIAL HANDLING EQUIPMENT
BTC	BURN-IN/TEMP. CYCLING	OVE	OVENS
CAP	CAPP - SYSTEMS	PER	PERISHABLES
CEQ	CLEANROOM EQUIPMENT	POD	POTTING/DISPENSING
CLE	CLEANING EQUIPMENT	POJ	POWER TOOLS, JOINING EQUIPMENT
COM	CONSTRUCTION MATERIAL	PRE	PREPARATION EQUIPMENT
COP	CONTAINER, PACKAGING	PWB	PWB - SYSTEMS
COS	COMMUNICATION SYSTEMS	ROB	ROBOTICS
CWE	GENERAL WORKSTATION EQUIPMENT	SCS	SHOP CONTROL SYSTEMS
ESD	ELECTRO STATIC PROTECTION	SOW	SOLDERING, WELDING
FES	FEEDBACK SYSTEMS	TES	TESTER
IME	INJECTION MOLDING EQUIPMENT	WIN	WINDING EQUIPMENT
INS	INSPECTION EQUIPMENT	WOR	WORK STATIONS

PCI - TECHMOD 51/52

EQUIPMENT CODING SYSTEM

TYPICAL: M H E 0 0 1 - 0 0 1

(1) M H E — EQUIPMENT CODE

(2) 0 0 1 — EQUIPMENT SELECTION INDICATOR

(3) 0 0 1 — EQUIPMENT INDEX NUMBER

(e.g., number indicates material handling equipment (MHE), AGVS (001), FIRST # (001) - Litton AGVS Series 500 -

(1) Equipment Code: See equipment listing (ADH thru WOR)

(2) Equipment Sel. Indicator: See Equipment

(3) Index Number - Selected for each line as required.
- (For existing equipment use existing number)
- (Select new number for new equipment)

Note: XXX 999-001 Use this combination if equipment can't be specified due to reason's which can't be influenced from Tech. Mod. Team. (e.g., Barcode reading/I.D. System influenced by PMS/HMS).

Figure 8.18. Equipment Coding Key

DATE: 11/17/86

REV.:

SPECIFICATION SHEET

CAPITAL REQUIREMENT

ROB 001-001

ROBOT

A. Robot

Type: High Precision Clean Room Robot	
Controlled Axis: (Servo Controls)	6 Axis
Accuracy of Movement (Axis)	±0.00025 (.01 mm)
Repeatability	±0.0005 (.02 mm)
Controller: Single microprocessor controller, modular design	
Working Speed:	max. 1200 cycles/hour
Working in cleanroom environment	
Mount:	Table top mount
Swing Radius (Main Arm)	300 mm
Max. Swing Radius	190 mm
Covered Area:	ID = min. 300 mm, OD = 490 mm
Vertical Motion	25 mm
Max. Load	0.1Kg = .22 lbs.
Max. Force	10N = 21.6 lbs.
Swing Speed	400 Degrees/sec.

B. Controller:

Type: Multiprocessor System M
Memory: 16 K Byte, user memory max. 40 K Byte
20 inputs/outputs for sensors & actuators
RS232 interface
Teach Methods (Programming mode)

C. Pheripherals:

Printer
CRT-Terminal
Memory Source: Cassette/floppy disk

D. Safety Features:

Position detector, failure control, force limit, limit sensors, safety routines

Figure 8.19. Typical Equipment Specification Sheet (Robot for Spinmotor Assembly Cell)

Additionally, the "To-Be" factory concept was tested for how it would behave over a longer time period of continuous operation. The "WITNESS" program proved to be the ideal tool to meet these requirements; the animation portion of the program was especially helpful. The results of the GG1111/"To-Be" factory simulation proved that the factory design did not contain bottlenecks, yet indicated that quite a lot of the dedicated equipment was underutilized. This was not a surprise since it was built into the factory design in the form of dedicated special equipment.

This approach was costlier at first glance, but on the other hand, ensured Just-In-Time delivery and continuous line-flow through the assembly process, thereby reducing work-in-process (WIP) and inventory. With the "To-Be" factory design simulated and approved, the next step was to develop the final factory design in the form of a floor layout.

Plant engineering/space planners assisted in determining where the "To-Be" factory would be located. Obtaining a firm commitment on the availability of the space was next. Figure 8.20 depicts the space distribution as it was agreed upon and as it was made available to finalize the factory layout. Then the generic layout alternatives were developed to show the relationships and locations of the four product areas to each other. Six alternatives were developed for the "To-Be" factory. Alternative 1 (see Figure 8.21) was chosen and approved by management contingent on space availability at the time of anticipated occupation, autumn of 1987.

The team decided to co-locate the support staff according to function, allocating staff resources separately for each of the four product areas. This dedicated arrangement was congruent with the project's original objectives. Figure 8.22 shows the GG1111 final floor layout typical of the remaining areas. Each of the designs contains a buffer as the central logistics and preparation portion of the factory, with a kitting and buffer capacity of one to two days (maximum), along with necessary dispatching systems to the assembly areas. Subassembly and final assembly are divided by the centrally located buffer and only are connected through advanced material handling systems in the form of cycled or feeding conveyors and pneumatic tube systems. The latter ones are used primarily when operations have to be performed in areas remote from the main assembly lines. An automated guided vehicle system (AGVS) is the outside material handling link to the centrally located stores area, Fab Fac, and other areas.

Support offices are located around the periphery of both the subassembly and final assembly areas. Each area contains conference and break rooms, separate offices for supervisory personnel, and where necessary, rest rooms. Air locks are used for the entrance of the subassembly and the final assembly clean rooms. Each one of the areas is designed with its own computer control center, designed for controlling the logistics, data collection, and information flow within the area. Pneumatic tubes connect the sensor assembly areas (GG1111, GG4400, and GNAT) with the bearing room to simplify material handling among these areas. Gases like helium, CO_2, and argon, which are used for operations such as leak checking and laser welding, are stored at easily accessible points near aisles for handling and safety reasons. Connection to the user work cells/stations is made via piping. Further details on the overall operation sequence and equipment can be seen in the individual floor layout (Figure 8.22).

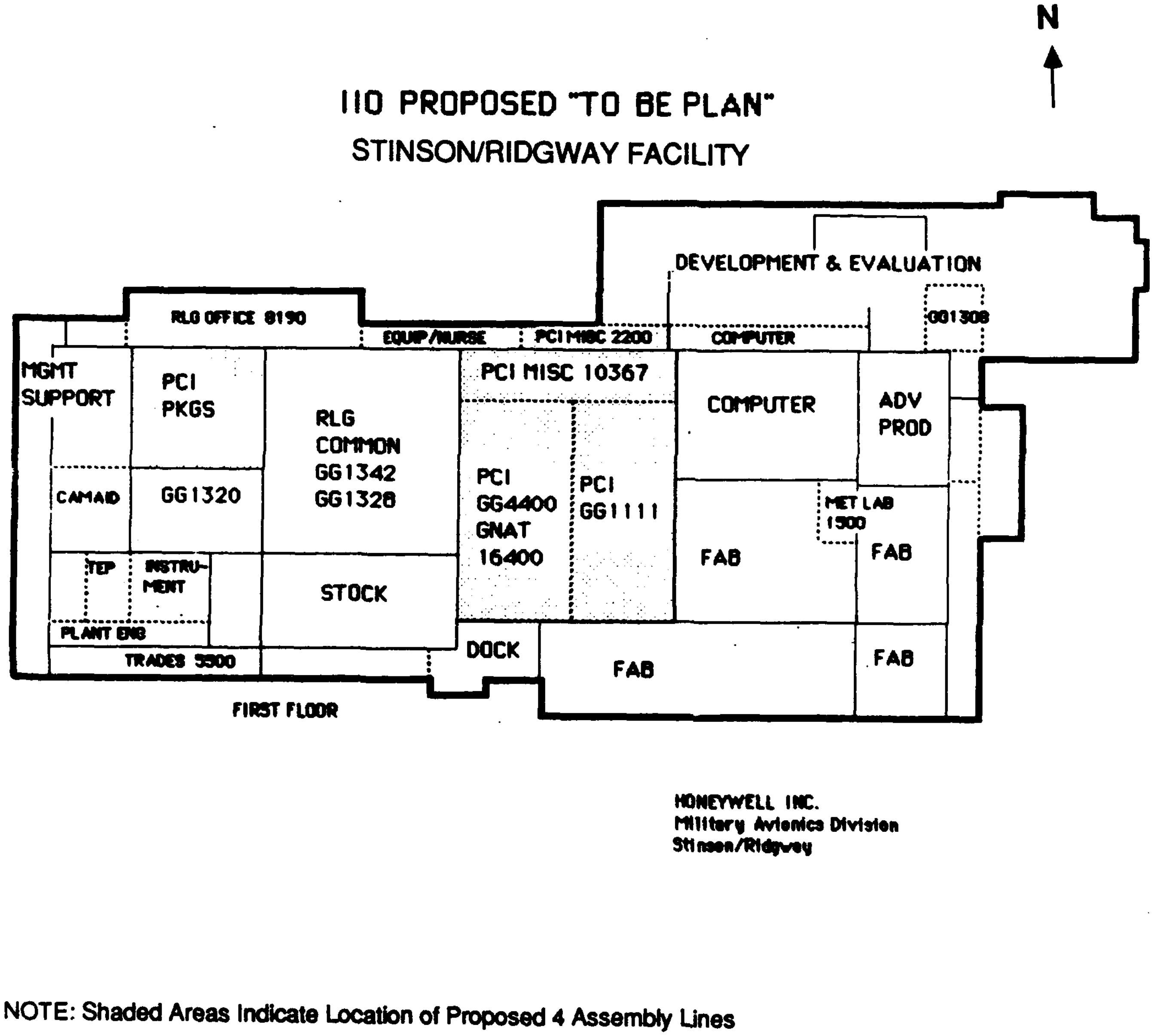
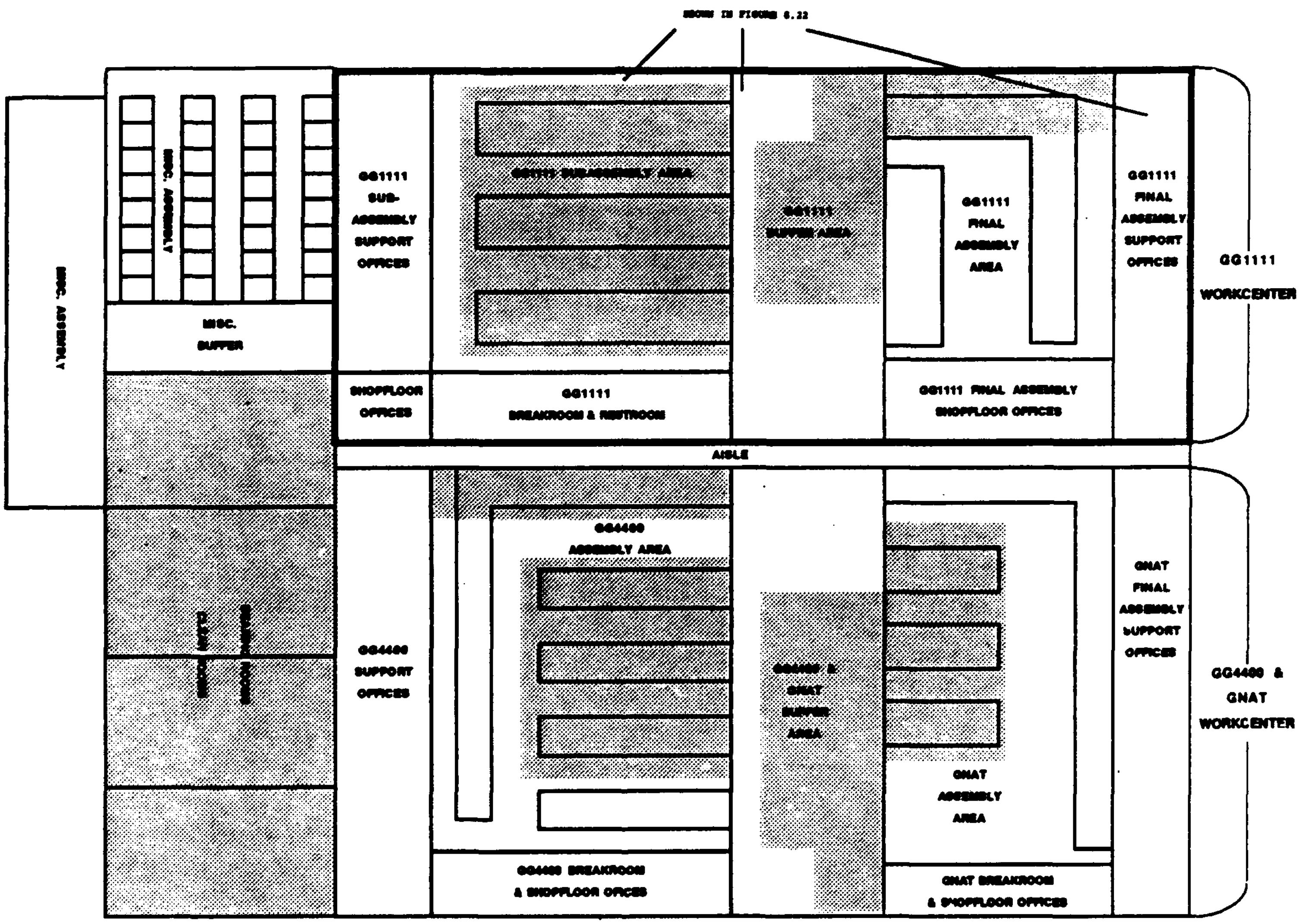


Figure 8.20. IIO Space Distribution for the "To-Be" Factory

ALTERNATIVE 1

PCI LAYOUT "TO-BE"



NOTE: SHADED AREAS ARE CLEANROOMS (AVERAGE: CLASS 100,000 & BETTER)

Figure 8.21. Layout Alternative for the "To-Be" Factory

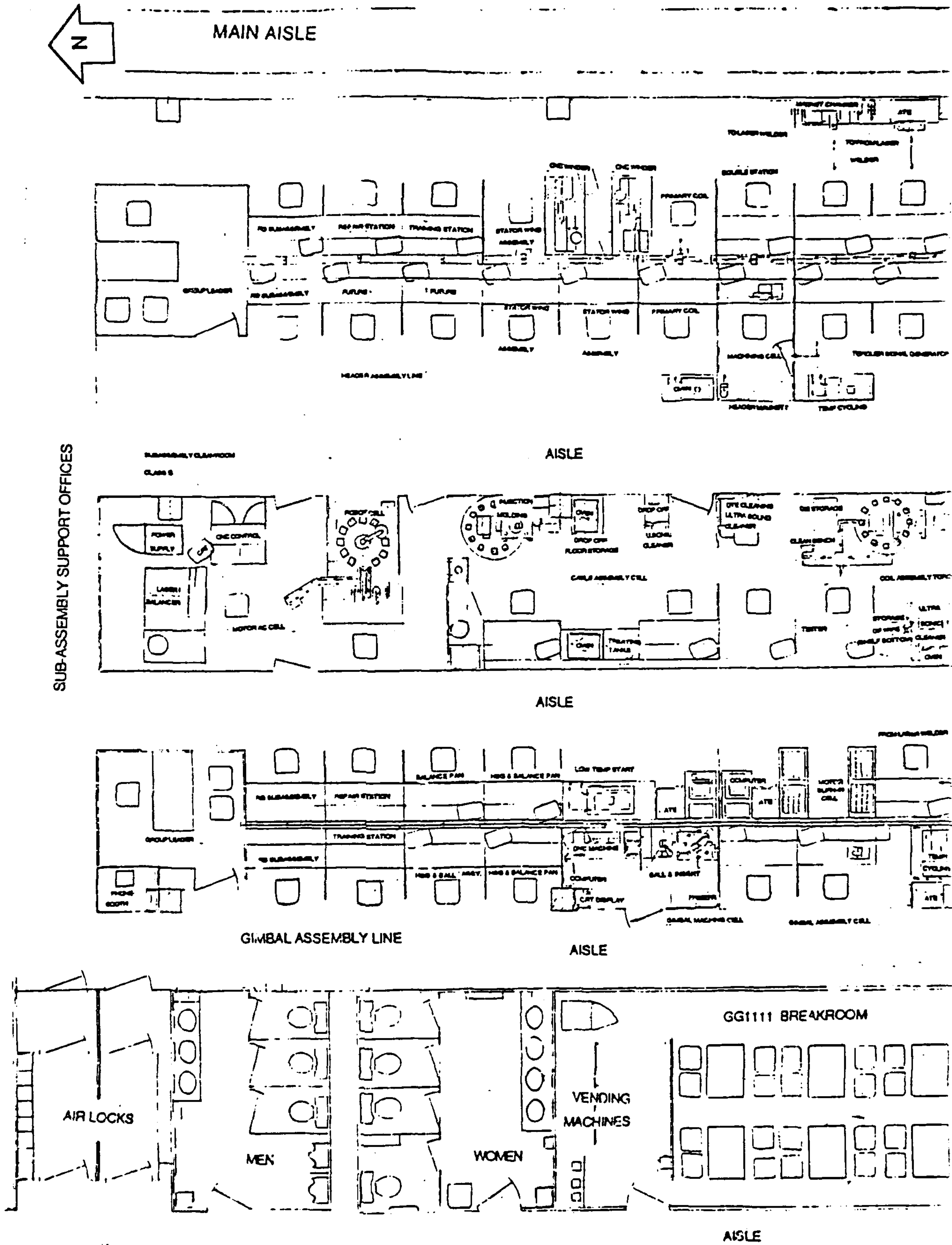
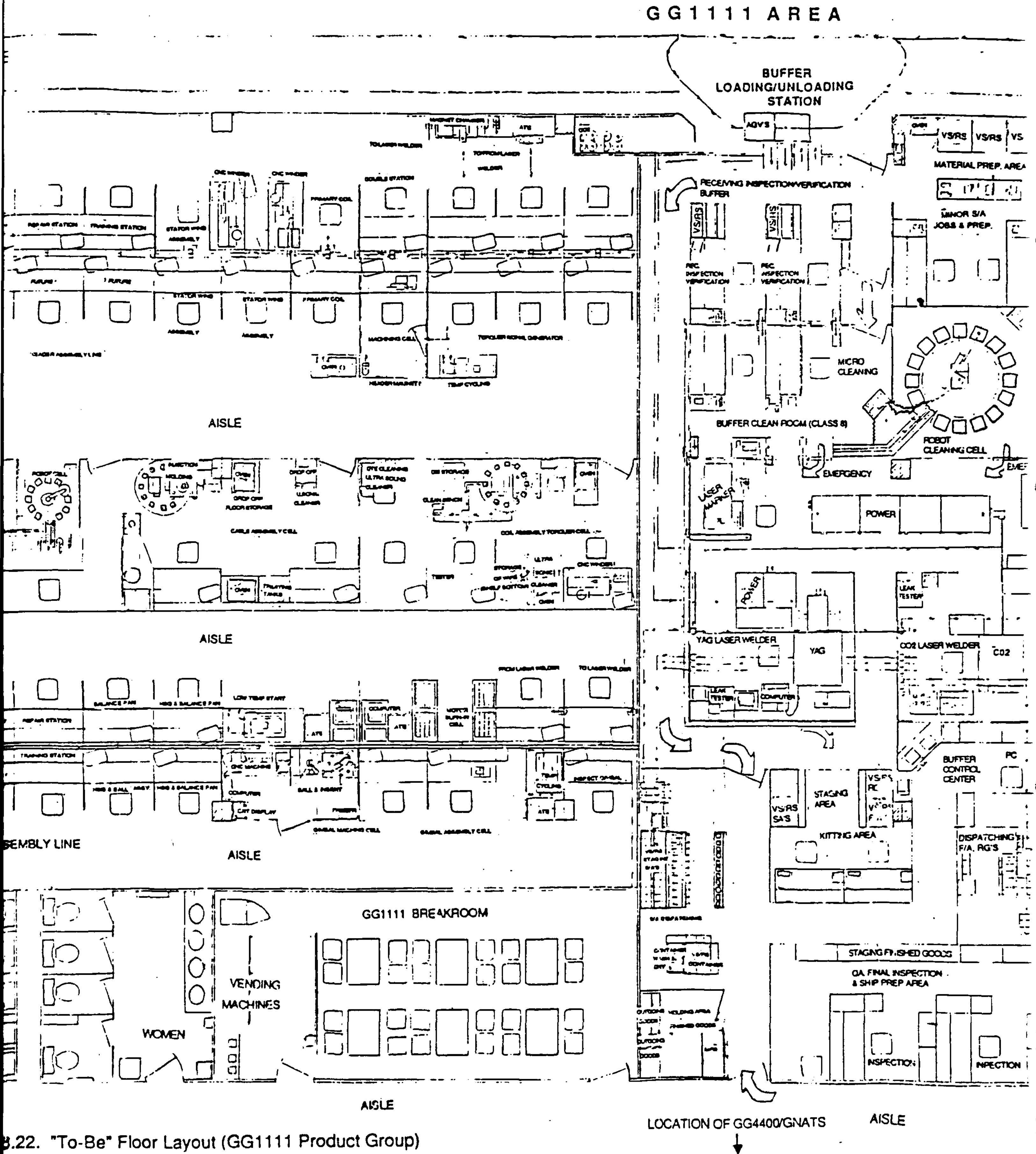


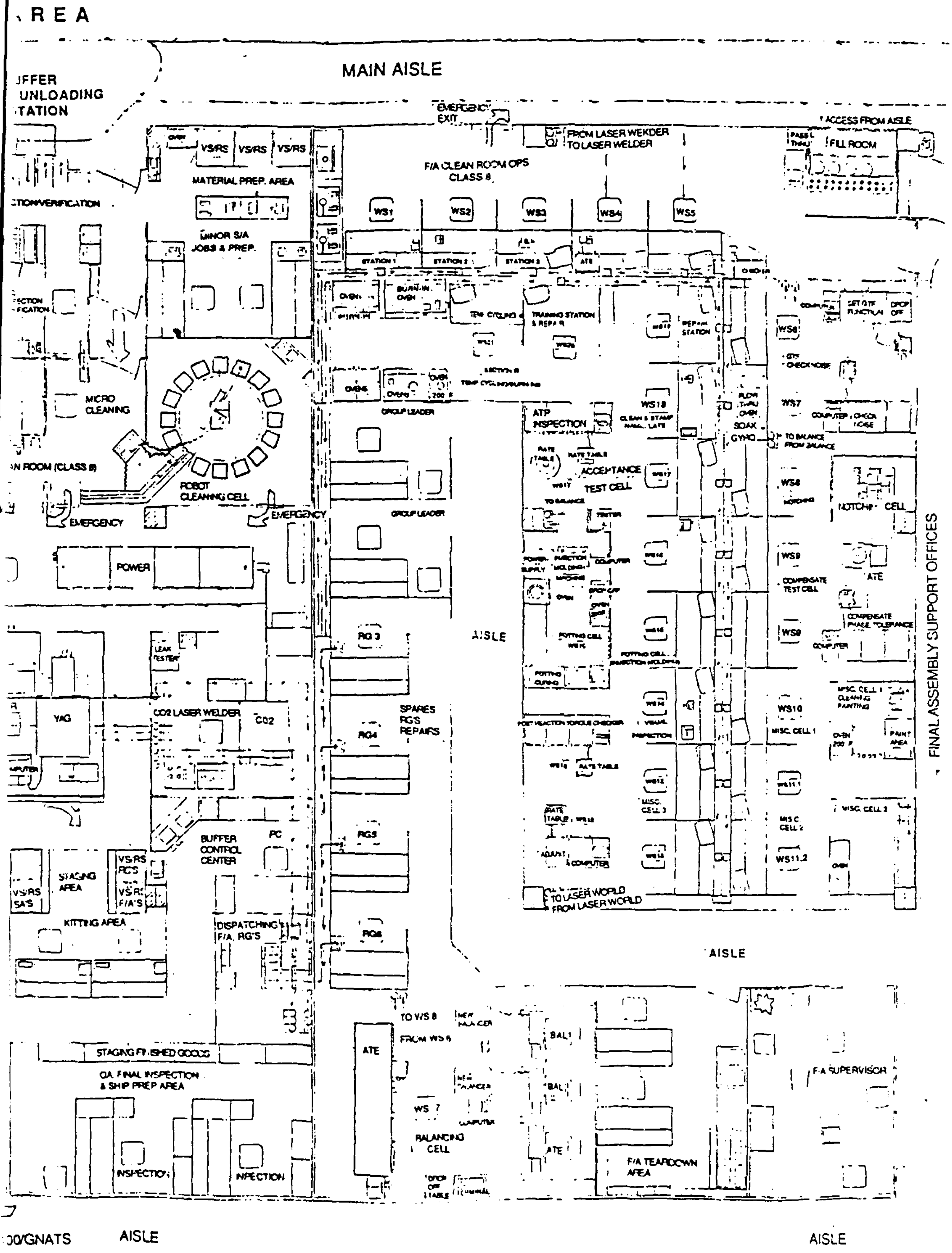
Figure 8.22. "To-Be" Floor Layout (GG1111 Product Group)

1 of 3



.22. "To-Be" Floor Layout (GG1111 Product Group)

2 of 3


REA
MAIN AISLE
JFFER UNLOADING TATION
EMERGENCY EXIT
FROM LASER WEKDER
TO LASER WELDER
ACCESS FROM AISLE
FILL ROOM
VS/RS
MATERIAL PREP. AREA
F/A CLEAN ROOM OPS CLASS 8
WS1
WS2
WS3
WS4
WS5
MINOR S/A JOBS & PREP.
STATION 1
STATION 2
STATION 3
ATE
BURN-IN OVEN
OVEN
TRAINING STATION & REPAIR
REPAIR STATION
WS6
OVENS
GROUP LEADER
MICRO CLEANING
ATP INSPECTION
WS18
FLOW THRU OVEN
SOAK
GYRO
WS7
ACCEPTANCE TEST CELL
WS8
NOTCHING CELL
ROBOT CLEANING CELL
EMERGENCY
POWER
WS9
COMPENSATE TEST CELL
ATE
COMPENSATE PHASE TOLERANCE
RG 3
AISLE
LEAK TESTER
POTTING CELL
YAG
CO2 LASER WELDER
C02
SPARES RGS REPAIRS
RG4
WS10
MISC. CELL 1
PAINT AREA
FINAL ASSEMBLY SUPPORT OFFICES
MISC. CELL 3
MISC. CELL 2
BUFFER CONTROL CENTER
PC
RG5
WS11.2
STAGING AREA
VS/RS SA'S
VS/RS RGS
VS/RS F/A'S
KITTING AREA
DISPATCHING F/A, RG'S
RG6
TO LASER WORLD
FROM LASER WORLD
AISLE
TO WS 8
FROM WS 6
BAL 1
BAL
ATE
STAGING FINISHED GOODS
QA FINAL INSPECTION & SHIP PREP AREA
WS 7
BALANCING CELL
F/A SUPERVISOR
F/A TEARDOWN AREA
INSPECTION
INPECTION
00/GNATS
AISLE
AISLE

3 of 3

SECTION 9

SYSTEM/EQUIPMENT/MACHINING SPECIFICATIONS

INTRODUCTION

The Honeywell MAvD IIO/PCI factory modernization project for inertial (iron) gyroscopes/sensors was initiated to convert the current production facility into a low cost, competitive, state-of-the-art production facility of tomorrow.

The project began with the formation of teams to design the individual work areas of GG1111, GG4400, GNAT, and Packages as well as to introduce the quality improvements outlined in Project 52 (combined with Project 51). The teams were assisted by a consultant from Gantner & Associates, Consultants (GAC) which specializes in modernization projects of this nature.

Since the modernization project addressed all aspects of a precision electro-mechanical production facility (from minor assembly and cleaning processes to complex balancing, functional testing, and shop floor control systems), the specifications encompass a wide array of equipment and systems.

PRELIMINARY EQUIPMENT DEFINITION AND REQUIREMENTS

The first step in developing equipment and system specifications for the new factory was the development of an equipment coding system that would be used to distinguish among the multitude of equipment pieces used in the new design. Figure 9.1 depicts the coding system and the equipment key as applied to the four product groups.

The collected information and literature on equipment and systems related to the project was cataloged and grouped into books using the equipment coding system. The information contained then was used as a general equipment catalog and data bank in selecting equipment for the "To-Be" process. Figure 9.2 shows a sample of the alphabetical summary of the equipment.

Upon completion, the catalogs contained high and low tech equipment of sizes ranging from miniature and table top to standalone. The catalogs included only equipment under consideration for the "To-Be" factory design. Some of the equipment selected for the new factory also were dedicated/tailored to specific processes utilizing higher degrees of automation. This equipment primarily was defined by using process-related requirements.

EQUIPMENT LISTING

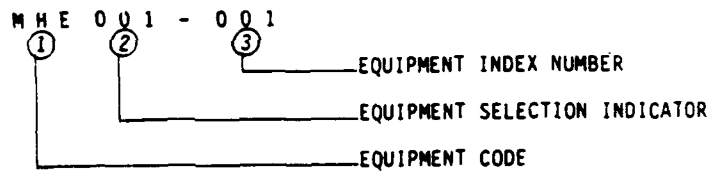
C O D I N G   K E Y

ADH	ADHESIVE/ADHESIVES EQUIPMENT	LAS	LASER EQUIPMENT
ASE	ASSEMBLY EQUIPMENT	MAC	MACHINE TOOLS
ATE	ATE - STATION	MEE	MEASURING EQUIPMENT
AUT	AUTOMATION/PHILOSOPHIES/CASES	MIT	MISCELLANEOUS TOOLS
BAR	BARCODE SYSTEM	MHE	MATERIAL HANDLING EQUIPMENT
BTC	BURN-IN/TEMP. CYCLING	OVE	OVENS
CAP	CAPP - SYSTEMS	PER	PERISHABLES
CEQ	CLEANROOM EQUIPMENT	POD	POTTING/DISPENSING
CLE	CLEANING EQUIPMENT	POJ	POWER TOOLS, JOINING EQUIPMENT
COM	CONSTRUCTION MATERIAL	PRE	PREPARATION EQUIPMENT
COP	CONTAINER, PACKAGING	PWB	PWB - SYSTEMS
COS	COMMUNICATION SYSTEMS	ROB	ROBOTICS
CWE	GENERAL WORKSTATION EQUIPMENT	SCS	SHOP CONTROL SYSTEMS
ESD	ELECTRO STATIC PROTECTION	SOW	SOLDERING, WELDING
FES	FEEDBACK SYSTEMS	TES	TESTER
IME	INJECTION MOLDING EQUIPMENT	WIN	WINDING EQUIPMENT
INS	INSPECTION EQUIPMENT	WOR	WORK STATIONS

PCI - TECHMOD 51/52

E Q U I P M E N T   C O D I N G   S Y S T E M

TYPICAL:



(e.g., number indicates material handling equipment (MHE), AGVS (001), FIRST # (001) - Litton AGVS Series 500 -

(1) Equipment Code: See equipment listing (ADH thru WOR)

(2) Equipment Sel. Indicator: See Equipment

(3) Index Number - Selected for each line as required.

- (For existing equipment use existing number)
- (Select new number for new equipment)

Note: XXX 999-001 Use this combination if equipment can't be specified due to reason's which can't be influenced from Tech. Mod. Team. (e.g., Barcode reading/I.D. System influenced by PMS/HMS).

Figure 9.1. Equipment Coding Key/System

EQUIPMENT   Oct 30, 1986

TYPE	CODE	DESCRIPTION	MANUFACTURE	PHONE
ASSEMBLY EQUIPMENT	ASE-001	TRANSISTOR LEAD FORMING SYSTEM	HEPCO, INC.	(408) 738-1060
ASSEMBLY EQUIPMENT	ASE-002	AUTOM. SENSING, SORTING & INS. EQUP	INSPECTOR GENERAL	
ASSEMBLY EQUIPMENT	ASE-003	TWEEZER HEAD PICK & PLACE SYSTEM	DYNAPERT-PRECIMA LTD	(617) 927-4200
ASSEMBLY EQUIPMENT	ASE-004	TURRET HEAD MICROPLACEMENT SYSTEM	DYNAPERT-PRECIMA LTD	(617) 927-4200
ASSEMBLY EQUIPMENT	ASE-005	MINI WIRE-WRAP SYSTEM	OK-INDUSTRIES	(212) 994-6600
ASSEMBLY EQUIPMENT	ASE-006	AUTOMATIC SCREWDRIVING MACHINE	WEBER	(612) 546-2960
ASSEMBLY EQUIPMENT	ASE-007	AUTOMATION EQUIPMENT, ACCESSORIES	AUTOMATION DEVICES,	(813) 446-9178
ASSEMBLY EQUIPMENT	ASE-008	AUTOMATION ELECTRONICS FACTORY, ART	ASSEM. ENGINEER.8/83	
ASSEMBLY EQUIPMENT	ASE-009	PRECISION ASSEMBLY & MDLG. SYSTEMS	MENZIKEN AUTOMATION	(704) 522-1135
ATE - STATIONS	ATE-001			
AUTOMATION	AUT-001	AUTOMATION CENTERS	BENERSON CORP.	(812) 428-2400
AUTOMATION	AUT-002	AUTOM. ASSEMBLY (CASES)	WELDUN AUTO (CASES)	(616) 695-0151

TYPE	CODE	DESCRIPTION	MANUFACTURE	PHONE
BARCODE SYSTEMS	BAR-001	BARCODE EQUIPMENT BUYER'S GUIDE	IE-MAGAZINE 9/86	
BARCODE SYSTEMS	BAR-002	BARCODE SYSTEMS	STANDARD REGISTER	(513) 443-1000
BARCODE SYSTEMS	BAR-003	SKAN-A-MATIC BAR CODE SYSTEMS	SKAN-A-MATIC	(315) 689-3961
BARCODE SYSTEMS	BAR-004	LINEAR BAR CODE PRINTER	SCANMARK	(603) 352-1130
BARCODE SYSTEMS	BAR-005	BAR CODE LABELING	FARGO	(612) 941-9470
BARCODE SYSTEMS	BAR-006	PRESSURE-SENSITIVE BAR CODE LBELING	YORK	(717) 846-4840
BARCODE SYSTEMS	BAR-007	BARCODES - REPORT	HIGH TEC. MAG. 7/86	
BARCODE SYSTEMS	BAR-008	BAR-CODE PRINTER	EATON PRINTER PRODS.	(307) 856-4821
BARCODE SYSTEMS	BAR-009	TAPE & MARKING SYSTEM	GETTIG	(814) 442-0892
BURN-IN/TEMP. CYCLING	BTC-001	AUTOMATIC ENVIRONMENTAL TESTING	TENNEY	(201) 686-7870

Figure 9.2. Alphabetical Summary of Equipment Including Codes and Descriptions

Shelf type equipment was not considered since all equipment was of special design. The specialized equipment was aimed at replacing the Fabrication Facilities (Fab Fac) machining operations in PCI. The goal was to perform machining operations in-line with assembly processes for those machining operations which had to be performed within the assembly sequence.

General equipment was selected with the following overall requirements in mind:

- Size: miniaturized and compact to meet space requirements.
- Operator friendly; simple to operate.
- High automation level.
- Must operate in-line with the paced assembly line.
- Must be integratable in the overall manufacturing system.
- Larger automated equipment must be able to communicate with the factory control system (WCM, FDC, HMS).
- Equipment set-ups must be either zero or automated and initiated through barcode identification.
- Equipment for thermal processes should be designed as flow-through systems.
- High reliability/low maintenance.
- High accuracy/repeatability for machining equipment.
- All equipment must meet safety requirements.
- Must meet clean room requirements.
- Should use existing power sources.
- Reasonable price.

Computer systems and controls which are not related to factory equipment, such as the barcode identification system (FDC), shop floor control system (WCM), and the computer-aided process planning package (CAPP) were selected primarily on the basis outlined under factory specifications. The approach for the development and the specifications themselves are described in Section 13, Management Information Systems (MIS) Requirements/Improvements.

Specification forms were designed for internal use and for requesting quotes. Each form contained individual equipment codes and descriptions, columns for data and revision letters for controlling changes and modifications, and technical details grouped and listed below the equipment code. Examples of these specifications sheets, which display technical specifications for a selected number of smaller and larger pieces of equipment as planned for the new factory, are shown in Figure 9.3. To reduce time for developing the numerous specification sheets, it was decided to focus on high dollar items first (i.e., borderline $5 to $10 K) and downscale the effort for developing forms for the smaller pieces of equipment. If required, these forms would be expanded in the implementation phase to incorporate unique requirements and details for procurement. The multitude of small tools and table top equipment have been priced using particular catalogues without developing special specification sheets.

Specification forms for high dollar items, like automated test equipment (ATE), have been developed with the assistance of production and quality engineering and verified/revised by an application engineer from Honeywell's Test Systems and Logistics Operations (TSLO), which will be the internal (MAvD) manufacturer of this equipment. At this time it was decided to upgrade and retrofit existing test equipment rather than buying new equipment. Exception to this rule is equipment which is needed for the purpose of expansion or capacity increases, as in the case of balancing and test equipment for the GG1111 factory. Specifications for these test stations primarily show modifications and changes of existing equipment instead of a complete list of details for the entire station.

The new "To-Be" processes, as documented in Figure 9.4, cross-reference each one of the selected pieces of equipment by assembly and operation number. Equipment which might be used in any of the four product areas has the same equipment code and the same specification sheet, thus allowing for a cross-reference beyond the limits of one individual product area.

Existing equipment which continues to be used in the "To-Be" factory is listed on the computer spreadsheets ("To-Be" process) under the current equipment code. Figure 9.4, which depicts the new "To-Be" processes of GNAT final assembly, is an example of how equipment codes are used and recorded related to the "To-Be" processes. At the conclusion of the equipment selection for each work center/assembly line, a summary was prepared listing all pieces of equipment which had been selected and were required in this particular area. Figure 9.5 shows an example of the equipment requirements listing for the GG1111 final assembly area. This is typical of other areas as well.

Lead times and equipment prices on these lists were added only after receiving quotations for the various pieces of equipment. Prices then were reviewed with the vendor, and as required in some cases, prices and specifications were corrected and revised to meet the factory requirements. All of the quotes were based on the previously developed specification sheets, which were sent out along with the requests for quote (RFQ) to the selected vendors. Since this project, in contrast to other Tech Mod projects, had to deal with numerous pieces of equipment and an extended list of individual equipment and tooling, it was expected that vendor response would be too late to be considered in the factory cost summary.

DATE: 11/17/86

REV.:

SPECIFICATION SHEET

MHE001 - 001

CAPITAL REQUIREMENT

AUTOMATED GUIDED VEHICLE

1. VEHICLE SYSTEM:

- Automated Material Transfer/Handling System
- W/Shuttle (Container) transfer system (Autoamtic Pick-up & Delivery)
- Light version for use in Electronic Manufacutring
- With Chemical/Optical Guidance System
- With safety feature & automatic stop when colliding with human or mechanical obstacle
- With tight turning radius, 2 wheel design
- Battery operated (low battery voltage alarm)
- Tracking Accuracy ±.25" (or better)
- Stopping accuracy min. ±.25"
- Forward speed 100 ft./min., variable from 15 ft./min. to 95 ft./min. (Controlled thru micro-processor)
- Braking: controller by micro-processor (programmed deceleration)
  - Scheduled stops
  - Immediate braking/safety stops
- Power: 24 V, DC 180 amp. battery pack
- Time between charging of battery: 8 Hours
- Dimensions: Vehicle Width = 24"
  Vehicle Width = 58"
  Vehicle Total Height = 56"
  Vehicle Container Size max.: = 9" X 22"

2. CONTROLS

- Micro-processor control & on-board RAM-Memory
- With Remote Command Capability
- Manual overriding mode
- Steer angle 90° to right, 90° to left, 0.8° increments

3. HOST COMPUTER:

- Direct communication with AG's thru host computer via. FM-Data link & base station
- Base Station:
  - Two-way radio
  - Modem
  - Antenna
  - Power Supply
  - Interconnecting Cables & R232C interface

Figure 9.3. Equipment Specification Sheet

TECH MOD 51/82. TO-BE PROCESS - GNAT GYRO
FINAL ASSEMBLY GNAT (ALL VERSIONS) (GNAT FA)

CYCLE TIME (CT) = 407 M/HRS

PAGE 1 OF 11
ISSUE 5
DATE 6/11/87

#	OP #	OPERATION DESCRIPTION DETAIL	A VAC ABST %	B LINE EFF %	C DOWN TIME %	D STD HRS (H/M)	E ADJ STD HRS (H/M)	F MANPOWER BY OP	G MANPOWER W/VAC & ABST	H PROCESS TIME W/O LAB. (HRS)	I # OF STAG POINTS	J PROCESS TIME + LABOR (HRS)	K ELAPSED TIME TOTAL (HRS)	TOOLING CODE	EQUIPMENT CODE	REMARKS
INPUT	INPUT	INPUT	INPUT	INPUT	INPUT	INPUT	[(D/B) + (D*C)]	[E/CT]	[(A*E)/CT]+F	INPUT	E/1000 + H*C + (H/CT/1000)	E/1000 + H(1 + C)	CUM OF J			
1	GENERAL	NOTE: THE NEW TO-BE PROCESS FOR GNAT IS BASED ON					0.00	0.00	0.00		0.00	0.00	0.00			INFO ONLY
2		THE PRESENT GYRO DESIGN. TECH MOD DOES NOT PROPOSE					0.00	0.00	0.00		0.00	0.00	0.00			
3		DESIGN CHANGES FOR GNAT BUT RECOMMENDS TO					0.00	0.00	0.00		0.00	0.00	0.00			
4		CHANGE OVER FROM GOLD PLATING TO A LESS COSTLY/					0.00	0.00	0.00		0.00	0.00	0.00			
5		TIMELY SURF. FINISH PROCESS (E.G. BLACK ANODIZING)					0.00	0.00	0.00		0.00	0.00	0.00			
6							0.00	0.00	0.00		0.00	0.00	0.00			
7	GENERAL	NOTE: THE SUPPLY OF PARTS TO THE FINAL ASSEMBLY					0.00	0.00	0.00		0.00	0.00	0.00			REPLACE GOLD
8		LINE IS ACCURATELY TIMED TO THE LINE CYCLE OF THE					0.00	0.00	0.00		0.00	0.00	0.00			PLATING THRU
9		GNAT LINE - THE TIMING IS CLOCKED/SEQUENCED THRU					0.00	0.00	0.00		0.00	0.00	0.00			BLACK ANODIZING
10		COMPUTER AND A SHOP FLOOR CONTROL SYSTEM, AND					0.00	0.00	0.00		0.00	0.00	0.00			& DO IN BUFFER
11		IS CONTROLLED BY THE BUFFER AREA.					0.00	0.00	0.00		0.00	0.00	0.00			OF GNAT AREA
12		- ALL OF THE PROCESSES ARE PERFORMED IN THE					0.00	0.00	0.00		0.00	0.00	0.00			
13		PROPOSED TO- BE FINAL ASSEMBLY LINE.					0.00	0.00	0.00		0.00	0.00	0.00			
14							0.00	0.00	0.00		0.00	0.00	0.00			
15	GENERAL	ACCORDING TO BOM, PARTS & SUBASSEMBLIES ARE KITTED					0.00	0.00	0.00		0.00	0.00	0.00			INFO ONLY
16		IN THE BUFFER AREA FOR THE FINAL ASSEMBLY LINE,					0.00	0.00	0.00		0.00	0.00	0.00			
17		TYPICALLY A KIT CONTAINING THE FOLLOWING:					0.00	0.00	0.00		0.00	0.00	0.00			
18		- PICKOFF GIMBAL, SUBASSEMBLY					0.00	0.00	0.00		0.00	0.00	0.00			
19		- COMPENSATOR ASSEMBLY					0.00	0.00	0.00		0.00	0.00	0.00			
20		- THERMISTOR ASSEMBLY					0.00	0.00	0.00		0.00	0.00	0.00			
21		- PADDLE ASSEMBLY					0.00	0.00	0.00		0.00	0.00	0.00			
22		- OUTER GYRO HOUSING					0.00	0.00	0.00		0.00	0.00	0.00			
23		- FINAL ASSEMBLY PARTS KIT (SEE BOM)					0.00	0.00	0.00		0.00	0.00	0.00			
24		ALL PARTS/SUBASSEMBLIES ENTER THE FINAL ASSEMBLY					0.00	0.00	0.00		0.00	0.00	0.00			
25		LINE AS A COMPLETED KIT.					0.00	0.00	0.00		0.00	0.00	0.00			
26							0.00	0.00	0.00		0.00	0.00	0.00			
27	BUFFER	RECEIVE PARTS FROM FAB FAC AND IO-STORES.					0.00	0.00	0.00		0.00	0.00	0.00		MHE-001-001	
28		- READ IN BARCODE AND COMPUTER VERIFIES PARTS					0.00	0.00	0.00		0.00	0.00	0.00		BAR-000-001	
29		- DIMENSIONALLY CHECK AND VISUALLY CHECK PARTS					0.00	0.00	0.00		0.00	0.00	0.00			
30		- VAPOR DEGREASE AND MICRO CLEAN PARTS AS REQUIRED					0.00	0.00	0.00		0.00	0.00	0.00		ROB-002-001	
31		- MICROSCOPIC CHECK FOR CLEANLINESS					0.00	0.00	0.00		0.00	0.00	0.00		INS-046-001	
32		- BARCODE AS REQUIRED AND QUEUE (FOR KITTING)					0.00	0.00	0.00		0.00	0.00	0.00		BAR-005-001	
33							0.00	0.00	0.00		0.00	0.00	0.00			
34	BUFFER	- LASER SCRIBE OUTER HOUSING					0.00	0.00	0.00		0.00	0.00	0.00		LAS-008-001	
35	015	- PUT IN HOLDING FIXTURE & ALIGN FOR MARKING					0.00	0.00	0.00		0.00	0.00	0.00			
36		- LASER SCRIBE/MARK GYRO MODEL #					0.00	0.00	0.00		0.00	0.00	0.00			
37		- REMOVE FROM HOLDING FIXTURE & CHECK MARKING					0.00	0.00	0.00		0.00	0.00	0.00			
38		- VAPOR DEGREASE & MICRO CLEAN (AS REQUIRED)					0.00	0.00	0.00		0.00	0.00	0.00			
39							0.00	0.00	0.00		0.00	0.00	0.00			
40							0.00	0.00	0.00		0.00	0.00	0.00			

Figure 9.4. Equipment Codes ("To-Be" Processes)

EQUIPMENT REQUIREMENTS DETAIL

FOR: GG1111 FINAL ASSEMBLY LINE

SHEET 1 of 4

#	EQUIPMENT CODE		QUANTITY	EQUIPMENT DESCRIPTION	DIMENSION	LOC OP	CLEAN ROOM Y/N	NEW/ EXIST/ MOD	VENDOR	LEAD TIME WEEKS	TOTAL PRICE ($000)
1	WOR	SN 002,012-040	20	WORK BENCHES	2.5'X 5'	F	Y/N	N	WILFAR	8	50.00
2	WOR	SN 005-	30	SHOP TYPE CHAIRS	-	F	Y/N	E	HONEYWELL	-	AVAIL
3	WOR	SN 002,035-038	4	LAMINAR FLOWBENCHES	2.5' X 5'	F	N	N	WILFAB	8	10.00
4	F2	-	1	ROUND CONFERENCE TABLE(FA-SUPERVISOR)	4' DIA	F	N	N	HAWORTH	6	0.25
5	F1-F18	-	3	SUPERVISORS DESKS	2.5' X 5'	F	N	N	HAWORTH	6	135.00
6	-	-	10	OFFICE CHAIRS (SUPERVISORS OFFICE)	-	F	N	N	HAWORTH	6	2.00
7	F4	-	2	OFFICE CABINETS(SUPERVISORS OFFICE)	1.5'X3'X3'	F	N	N	HAWORTH	6	0.60
8	WOR	002,012-016	5	LAMINAR FLOW BENCHES	2.5' X 5'	E	Y	N	DEXON	6	11.00
9	-	-	27	CRT MONITORS (M-MODEL EP)	SPEC	S	N	N	INCLD IN SYSTEM	-	0.00
10	BAR	999,012-037	24	BAR CODE READERS(MODEL TPS,CODE 39)	SPEC	S	N	N	DYTECH	4	15.69
11	INS	846,009-022	14	TABLE TOP SHOP MICROSCOPES	-	E	N	E	HONEYWELL	-	AVAIL
12	MHE	003-002	1	PNEUMATIC TUBE-CONVEYOR (3"DIA X 72')	SPEC	E	N	N	SPCI	8	2.16
13	MHE	003-003	1	PNEUMATIC TUBE-CONVEYOR (3"DIA X 58')	SPEC	E	N	N	SPCI	8	1.74
14	MHE	003-004	1	PNEUMATIC TUBE-CONVEYOR (3"DIA X 70')	SPEC	E	N	N	SPCI	8	2.10
15	MHE	003-005	1	PNEUMATIC TUBE-CONVEYOR (3"DIA X 52')	SPEC	E	N	N	SPCI	8	1.56
16	MHE	003-006	1	PNEUMATIC TUBE-CONVEYOR (3"DIA X 38')	SPEC	E	N	N	SPCI	8	1.14
17	MHE	007-010	2	DOUBLE TIER CONVEYOR SYSTEM RG AREA	1' X 24'	E	N	N	RAAYMOND/TBD	8	8.16
18	MHE	007-010	8	DROP OFF/PICK OFF CONVEYOR PIECES RG AREA	1' X 1'	E	N	N	RAYMOND/TBD	8	1.60
19	MHE	007-003	1	MOTORIZED SUPPLY CONVEYOR (TO F/A LINE)	6"W X 46'	E	N	N	JERGENS/TBD	9	7.82
20	MHE	007-004	1	MOTORIZED SUPPLY CONVEYOR(TO F/A LINE)	6"W X 46'	E	N	N	JERGENS/TBD	9	7.82
21	MHE	007-004	1	MOTORIZED CYCLE CONVEYOR(6"W MODEL CST)	6"W X 28'	E	N	N	JERGENS/TBD	9	4.76
22	MHE	007-008	1	MOTORIZED CYCLE CONVEYOR(6"W MODEL CST)	6"W X 27'	E	N	N	JERGENS/TBD	9	4.59
23	MHE	007-005	1	MOTORIZED CYCLE CONVEYOR(6"W MODEL CST)	6"W X 41'	E	N	N	JERGENS/TBD	9	6.97
24	MHE	007-007	1	MOTORIZED CYCLE CONVEYOR(6"W MODEL CST)	6"W X 40'	E	N	N	JERGENS/TBD	9	6.80
25	MHE	007-006	1	MOTORIZED CYCLE CONVEYOR(6"W MODEL CST)	6"W X 15'	E	N	N	JERGENS/TBD	9	0.26
26	-	CLEANROOM	3	SHOP BENCHES(SMALL) USED AS STANDS	2' X 3' X 3.5'	E	N	N	HAYWORTH/TBD	6	0.90
28	INS	015-006	1	CONTINUITY/DIELECTRIC TESTER(COMPUTERIZED)	SPEC	E	Y	N	FLUKE/TBD	6	39.00
29	CLE	CLE |002-005	1	MINI-ULTRASONIC DEGREASER & TANK	SPEC	E	Y	E	HONEYWELL	-	AVAIL
30	MEE	010-001	1	PRECISION PADDLEGAP MEASURING DEVICE	SPEC	E	Y	N	TBD	20	17.50

Figure 9.5. Equipment Requirements (GG1111 Final Assembly)

To meet these constraints and to ease the time problem, it was agreed to use just one instead of three competitive quotations for developing the factory costs. This was important since all equipment prices would have to be requoted prior to the Phase III implementation, which at this point, is still more than one year away. This time frame exceeds the usual validity time frames of equipment quotes. A contingency factory of 15% has been added to counteract price increases and equipment start up costs, since some of the equipment is tailored to the needs of the new factory and has to be tried out first.

Bids were evaluated by the project team before prices were used in the computation of the new factory costs. One of the team members acted primarily as the interface for requesting quotes, communicating with the various vendors, and revising quotations and prices. This arrangement minimized duplication of effort and kept the number of equipment types to a minimum. The equipment requirements summaries, shown in Figure 9.5, reflect these equipment pricing efforts.

SECTION 10

TOOLING SPECIFICATIONS

INTRODUCTION

The Honeywell MAvD IIO/PCI factory modernization project for inertial (i.e., iron) gyroscopes/sensors was initiated to convert the current factory into a low cost, competitive, state-of-the-art production facility.

Since Project 51/52 addressed all areas of a precision electro-mechanical production facility -- from minor assembly and cleaning processes to operations like sensor balancing, functional testing, and other complex and delicate processes -- concepts/specifications had to be developed for a wide range of very specialized fixtures and general tooling. For assignments of this nature, Honeywell customarily employs internal tool designers. Consequently, a tool designer from IIO's tool design department was assigned to the project to conceptualize and develop specifications for the new and modified tooling identified for the "To-Be" factory.

The "make/buy" decision was made in favor of "make in-house" due to this being stipulated in the current union agreements between Honeywell and the Local 1145 Teamster's union.

PRELIMINARY TOOLING REQUIREMENTS AND DEFINITION

The first three tasks which had to be completed prior to developing tooling concepts and specifications for the "To-Be" factory were the following:

- Preparation of detailed descriptions of "To-Be" processes by product group as a basis for developing new tooling concepts.
- Definition of a general level of technology for tooling.
- Development of a tooling coding system to distinguish among the various tools of the new factory.

Figure 10.1 depicts a typical "To-Be" process write-up as it was developed for the new factory. The example shown is an excerpt of the GNAT-Final Assembly write-up. The processes were developed previously by the Tech Mod team as part of the Statement of Work (SOW) under the final design tasks. These computer write-ups of the final "To-Be" processes have been used as major guidelines for developing matching tooling concepts for the four product groups.

TECH MOD 51/02: TO-BE PROCESS - GNAT GYRO
FINAL ASSEMBLY GNAT (ALL VERSIONS) (GNAT FA)

CYCLE TIME (CT) = 407 M/HRS

#	OP #	OPERATION DESCRIPTION DETAIL	A VAC ABST %	B LINE EFF %	C DOWN TIME %	D STD HRS (H/M)	E ADJ STD HRS (H/M)	F MANPOWER BY OP	G MANPOWER W/VAC & ABST	H PROCESS TIME W/O LAB (HRS)	I # OF STAG POINTS	J PROCESS TIME + LABOR (HRS)	K ELAPSED TIME TOTAL (HRS)	TOOLING CODE	EQUIPMENT CODE	REMARKS
INPUT	INPUT	INPUT	INPUT	INPUT	INPUT	INPUT	[(D/B) + (D*C)]	[E/CT]	[(A*E)/ CT]+F	INPUT	E/1000 + H*C+ (H/CT/1000)	E/1000 + H(1 + C)	CUM OF J			
1	GENERAL	NOTE: THE NEW TO-BE PROCESS FOR GNAT IS BASED ON					0.00	0.00	0.00		0.00	0.00	0.00			INFO. ONLY
2		THE PRESENT GYRO DESIGN. TECH MOD DOES NOT PROPOSE					0.00	0.00	0.00		0.00	0.00	0.00			
3		DESIGN CHANGES FOR GNAT BUT RECOMMENDS TO					0.00	0.00	0.00		0.00	0.00	0.00			
4		CHANGE OVER FROM GOLD PLATING TO A LESS COSTLY/					0.00	0.00	0.00		0.00	0.00	0.00			
5		TIMELY SURF. FINISH PROCESS (E.G. BLACK ANODIZING)					0.00	0.00	0.00		0.00	0.00	0.00			
6							0.00	0.00	0.00		0.00	0.00	0.00			
7	GENERAL	NOTE: THE SUPPLY OF PARTS TO THE FINAL ASSEMBLY					0.00	0.00	0.00		0.00	0.00	0.00			REPLACE GOLD
8		LINE IS ACCURATELY TIMED TO THE LINE CYCLE OF THE					0.00	0.00	0.00		0.00	0.00	0.00			PLATING THRU
9		GNAT LINE - THE TIMING IS CLOCKED/SEQUENCED THRU					0.00	0.00	0.00		0.00	0.00	0.00			BLACK ANODIZING
10		COMPUTER AND A SHOP FLOOR CONTROL SYSTEM, AND					0.00	0.00	0.00		0.00	0.00	0.00			& DO IN BUFFER
11		IS CONTROLLED BY THE BUFFER AREA.					0.00	0.00	0.00		0.00	0.00	0.00			OF GNAT AREA
12		- ALL OF THE PROCESSES ARE PERFORMED IN THE					0.00	0.00	0.00		0.00	0.00	0.00			
13		PROPOSED TO- BE FINAL ASSEMBLY LINE.					0.00	0.00	0.00		0.00	0.00	0.00			
14							0.00	0.00	0.00		0.00	0.00	0.00			
15	GENERAL	ACCORDING TO BOM, PARTS & SUBASSEMBLIES ARE KITTED					0.00	0.00	0.00		0.00	0.00	0.00			INFO. ONLY
16		IN THE BUFFER AREA FOR THE FINAL ASSEMBLY LINE,					0.00	0.00	0.00		0.00	0.00	0.00			
17		TYPICALLY A KIT CONTAINING THE FOLLOWING:					0.00	0.00	0.00		0.00	0.00	0.00			
18		- PICKOFF GIMBAL, SUBASSEMBLY					0.00	0.00	0.00		0.00	0.00	0.00			
19		- COMPENSATOR ASSEMBLY					0.00	0.00	0.00		0.00	0.00	0.00			
20		- THERMISTOR ASSEMBLY					0.00	0.00	0.00		0.00	0.00	0.00			
21		- PADDLE ASSEMBLY					0.00	0.00	0.00		0.00	0.00	0.00			
22		- OUTER GYRO HOUSING					0.00	0.00	0.00		0.00	0.00	0.00			
23		- FINAL ASSEMBLY PARTS KIT (SEE BOM)					0.00	0.00	0.00		0.00	0.00	0.00			
24		ALL PARTS/SUBASSEMBLIES ENTER THE FINAL ASSEMBLY					0.00	0.00	0.00		0.00	0.00	0.00			
25		LINE AS A COMPLETED KIT					0.00	0.00	0.00		0.00	0.00	0.00			
26							0.00	0.00	0.00		0.00	0.00	0.00			
27	BUFFER	RECEIVE PARTS FROM FAB FAC AND SO-STORES.					0.00	0.00	0.00		0.00	0.00	0.00		MHE-001-001	
28		- READ IN BARCODE AND COMPUTER VERIFIES PARTS					0.00	0.00	0.00		0.00	0.00	0.00		BAR-999-001	
29		- DIMENSIONALLY CHECK AND VISUALLY CHECK PARTS					0.00	0.00	0.00		0.00	0.00	0.00			
30		- VAPOR DEGREASE AND MICRO CLEAN PARTS AS REQUIRED					0.00	0.00	0.00		0.00	0.00	0.00		ROB-002-001	
31		- MICROSCOPIC CHECK FOR CLEANLINESS					0.00	0.00	0.00		0.00	0.00	0.00		INS-846-001	
32		- BARCODE AS REQUIRED AND QUEUE (FOR KITTING)					0.00	0.00	0.00		0.00	0.00	0.00		BAR-005-001	
33							0.00	0.00	0.00		0.00	0.00	0.00			
34	BUFFER	- LASER SCRIBE OUTER HOUSING					0.00	0.00	0.00		0.00	0.00	0.00		LAS-008-001	
35	015	- PUT IN HOLDING FIXTURE & ALIGN FOR MARKING					0.00	0.00	0.00		0.00	0.00	0.00			
36		- LASER SCRIBE/MARK GYRO MODEL #					0.00	0.00	0.00		0.00	0.00	0.00			
37		- REMOVE FROM HOLDING FIXTURE & CHECK MARKING					0.00	0.00	0.00		0.00	0.00	0.00			
38		- VAPOR DEGREASE & MICRO CLEAN (AS REQUIRED)					0.00	0.00	0.00		0.00	0.00	0.00			
39							0.00	0.00	0.00		0.00	0.00	0.00			
40							0.00	0.00	0.00		0.00	0.00	0.00			

Figure 10.1. Typical "To-Be" Process Description (GNAT Final Assembly)

The next task for developing tooling concepts and specifications was to define general tooling guidelines and a level of tooling technology to be adhered to by the tool designer . This was essential to meet requirements for "To-Be" processes and the level of improvements designed into the new factory.

The criteria used as guidelines for the tooling conceptualization tasks are listed below:

- Size: miniaturized and compact to meet space requirements;
- Weight: light, especially if tool has to be handled manually by the operator;
- Concept/design must meet ergonomical design criteria;
- High mechanization/automation level;
- Must meet process requirements;
- Should integrate many functions/processes to minimize requirements for additional tooling;
- High accuracy to meet quality requirements;
- Reliable/sturdy to repeat functions correctly;
- Must meet safety requirements and have a reasonable cost.

The last step before developing "To-Be" tooling specifications for the new factory was defining a tooling coding system that would be used as the tooling numbering system in the new "To-Be" processes. This numbering system has been used to distinguish the various fixtures and tools and to reference where those tools will be used. Figure 10.2 depicts the tooling code for current and existing tooling as it is in use today. In some instances, the old tooling code will be used in parallel with the new tooling code in the "To-Be" design.

The new tooling code, used throughout the project when defining tooling numbers for new tooling in the "To-Be" factory, is shown in Figure 10.3. The new tooling code has been used exclusively for all new "To-Be" process write-ups (see Figure 10.1 under Tooling Code, marked with squares). The new tooling code replaces the old product identifier (e.g., GG1111, as shown in Figure 10.2) through two letters. The first letter, as explained in Figure 10.3, is the identifier for the product and end-user. The second letter, as shown in the GG1111 example, is used as an assembly identifier focussing on where the tooling is used with respect to assemblies. The third letter is simply an indicator for tooling, whereas the next 3 digits (item 4, Figure 10.3) are used for identifying the various tooling numbers within one assembly. Two digits, as an extension of the current number, indicate the issue/change number for revisions to tooling drawings (see Item 5, Figure 10.3). A "To-Be" tooling code example is shown in Figure 10.4. Miscellaneous/perishable tools (e.g., hand tools, masks) are not covered in this coding system. With preliminary requirements defined, conceptualizing and specifying of fixtures/tools began.

PRESENT PCI - TOOLING CODE "AS-IS"

USED FOR TOOLING GG1111, GG4400, GNATS, AND PACKAGES

```
                    *
E.G.,  |GG1111| - |T| |XXX|
                   |    |
                   |    |
  |__| |_____|     |    |
   |      |        |    |_ 3 DIGIT TOOLING NUMBER
   |      |        |       (e.g., 001..999)
   |      |        |
   |      |        |
   |      |        |_____ MANUFACTURING TOOLING INDICATOR
   |      |
   |      |
   |      |__________ FAMILY INDICATOR
   |                  (e.g., 1111, 4400, 1026, 1027, etc.)
   |
   |
   |_______________ GYRO INDICATOR
```

* OTHER LETTERS: E = TEST EQUIPMENT

G = GAUGES

|F| = OLD TOOLING ID (NOT USED ANYMORE)

NOTE: ISSUE * (CHANGE #'S) ARE NOT STAMPED ON THE TOOLING.

Figure 10.2. Honeywell MAvD/PCI Tooling Code for Existing Tooling

NEW TOOLING CODING SYSTEM ("TO-BE")

TYPICAL: A A - T XXX.XX

1 2 3 4 5

INDICATOR FOR GYRO TYPE

(e.g., Indicates tooling for F/A - GG1111 Gyros)

1. INDICATOR FOR GYRO TYPE

   A - GG1111

   B - GG4400

   C - GNAT

   D - PACKAGES

   E - MISCELLANEOUS

2. INDICATOR FOR ASSEMBLY ONLY

3. INDICATOR FOR TOOLING ONLY

4. TOOLING COUNTER OF EACH INDIVIDUAL ASSEMBLY - Shown on individual tooling sheets by assembly.

5. ISSUE/REVISION NUMBER - Identical to drawing issue number.

Figure 10.3. New Tooling Coding System for "To-Be" Factory

ASSEMBLIES AND SUBASSEMBLIES OF GG1111 GYRO

TO-BE TOOLING CODE/ASSEMBLY IDENTIFIER

1ST DIGIT CODE	2ND DIGIT CODE	PART NUMBER (e.g.)	DESCRIPTION
A	A	HONEYWELL PROPRIETARY DATA	RATE INT. GYRO - GG1111
	B		CABLE ASSEMBLY POWER
	C		PISTON AND BELLOWS ASSEMBLY
	D		COVER AND DISK
	E		PLATE AND BRIDGING
	F		TORQUER SIGNAL GENERATOR
	G		S.G. PRIM. COILS
	H		TORQUE SIGNAL GENERATOR (HEADER MAGNET
	I		HEADER ASSEMBLY
	J		BASE MACHING
	K		FLEX. RET. RING
	L		MOTOR & HOUSING ASSEMBLY
	M		BALL AND INSERT ASSEMBLY
	N		HOUSING & BALANCE PAN
	0		BALANCE PAN
	P		GIMBAL MOTOR END
	Q		HOUSING & BALL ASSEMBLY
	R		GIMBAL BAFFLE END
	S		MOTOR, AC. HYST.
	T		RING & LAMIN. HYST.
	U		STATOR WIND ASSY.
	V		PLATE H.T.
	W		STACK & SHAFT
	X		COIL ASSEMBLY & BOBBIN

Figure 10.4. "To-Be" Tooling Code/Assembly Identifier
(For Entire GG1111 Assembly)

TOOLING CONCEPTUALIZATION/SPECIFICATION

Upon completion of the preliminary tasks, tooling for the "To-Be" factory was conceptualized by using the previously described "To-Be" process write-ups (i.e., "To-Be" summaries), the tooling guidelines, the tooling coding system, and the current "As-Is" process and tooling information such as process summaries, parts prints, and tooling drawings. The tool designer observed first hand how operations are performed in the current "As-Is" factory and communicated directly with operators in order to gain clearer understanding of the manufacturing processes. Catalogues of equipment or tooling accessories were used whenever the design asked for interfaces with chosen new equipment, existing "As-Is" equipment, or hardware such as air cylinders.

In general, tooling concepts and specifications for each of the four product areas were discussed between the tool designer and Tech Mod team members prior to being finalized. Since many of the new "To-Be" processes have to be piloted before they can be finalized, all of the tooling concepts and specifications are contingent on successful piloting.

For explanatory purposes, several of the tooling concepts and specifications are described below. Figures 10.5 through 10.10 have been selected out of a multitude of tooling specifications as they were developed for the four product areas.

The tooling concept as shown in Figure 10.5 displays a typical cable connector mold/die as it will be required for injection molding of up to twenty-one versions of cable connectors for the GG1111 device. The dies will be used on vertical injection molding machines in the cable assembly cell of the new factory. The die is shown in size as it will fit into the new equipment. Heating and temperature sensing elements, which are required for thermal control of the injected plastic and for its proper cooling, are part of the die's design. Dies of this nature are usually clamped down on upper and lower platens of the equipment; therefore, the die has been designed with cut-outs/steps on both sides and on both die halves. A hole shown on the top half of the die depicts where the jet element is located for injecting the plastic into the cavity. The die will be made in several versions, according to the number of cable connectors needed in the GG1111 product group, and it then will be mounted on a quick changing mold changer/turret on the injection molding machine.

Figure 10.6 depicts a typical ball inserter and sealing press as it is used in the final assembly area of GG1111. This ball inserter and sealing press also is used with the GG4400/GNAT. The tool is used for inserting a heat treated polished ball into a seal hole, thus sealing off a hole which was used for filling purposes. As indicated through its air cylinder, the tool is operated pneumatically and only travels a restricted and precisely determined distance. The air cylinders are operated by means of foot-operated air valves. A ball feeder which is not shown (see detail on upper left hand corner) supplies the cleaned balls into the inserting sealing pin. A cavity, indicated as "gyro nest", holds the gyro tightly during the sealing process.

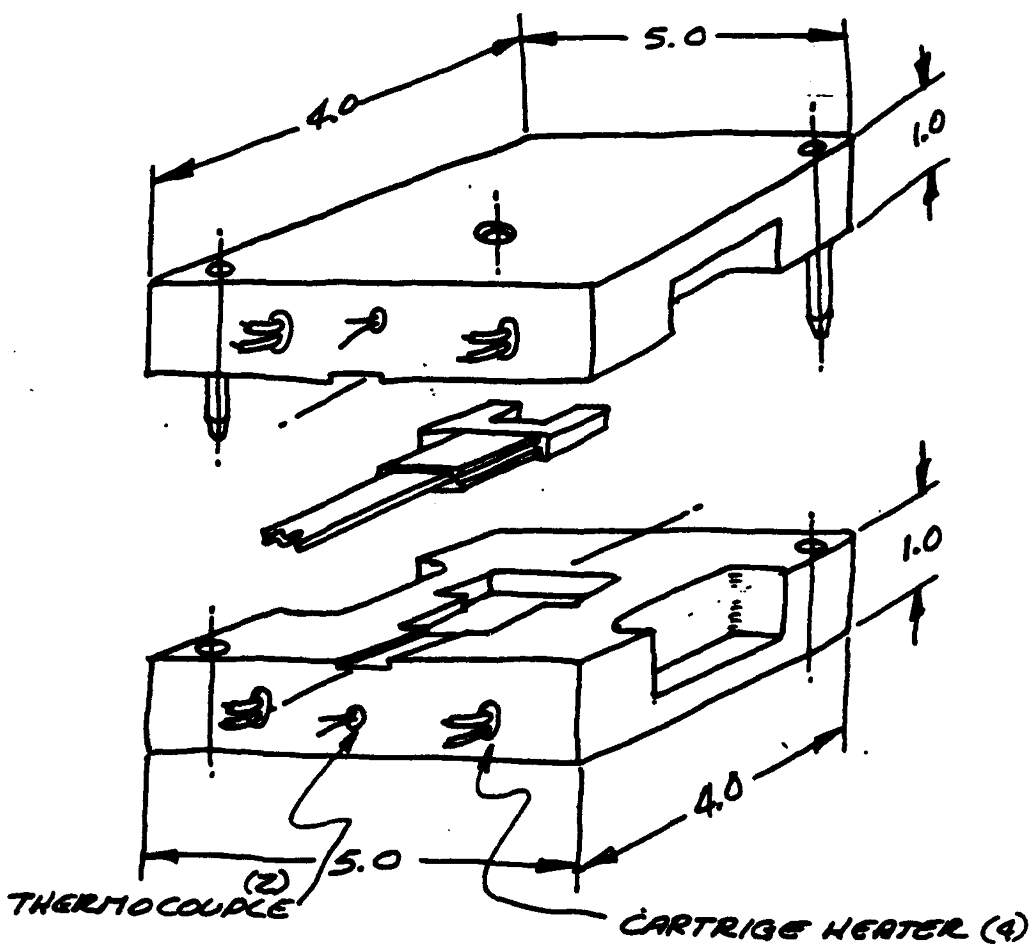


Figure 10.5. Concept/Specifications for Injection Molding Die (Cable Subassembly Cell)

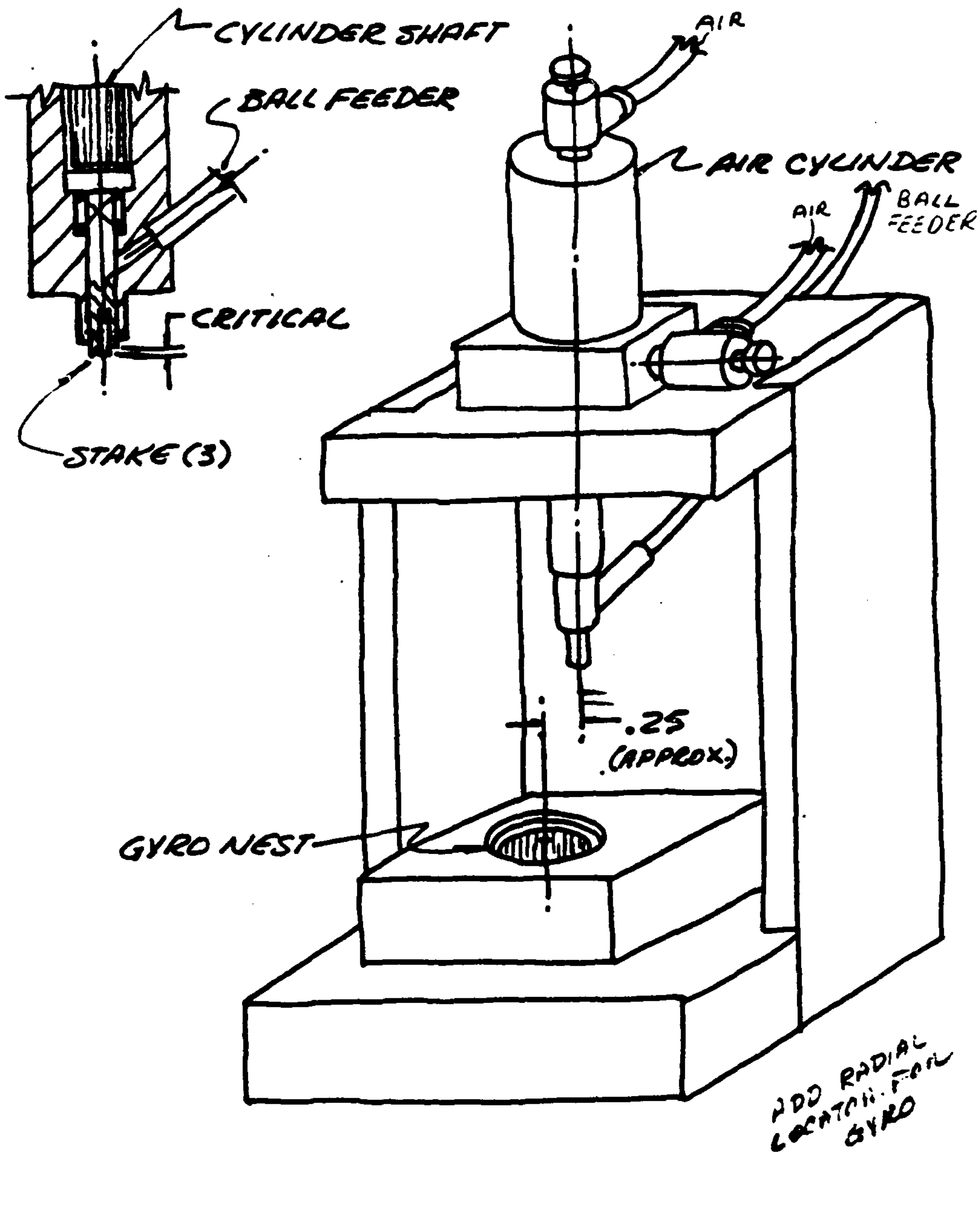


Figure 10.6. Ball Inserting/Sealing Press (Final Assembly Operation GG1111)

A pre-balancing and holding tool, shown in Figure 10.7., has been designed for assembly operations in the spinmotor and gimbal subassembly area. The design depicts a precision tool which is used in combination with a multiple (four) micro-spindle automatic screwdriver for fastening the two pillow blocks of the GG1111 gimbal/spinmotor mount in a pre-balanced position. Miniature air cylinders with micrometer screw set-up are used to position the spinmotor relative to the gimbal. A high precision transducer with digital read-out has been used to statically pre-balance the spin motor, thus minimizing the balance requirements after the gimbal has been hermetically closed. The design shown is a precision table top tool and is operated manually.

Figure 10.8 shows an integrated terminal trim and stripping tool for the GG1111 gimbal subassembly. The tool replaces a time consuming manual technique. The trim and stripping elements of the tool are operated pneumatically; a vacuum suction system, connected to the bottom of the tool, removes stripped insulation and pieces of wire used in the cleanroom. The tool is designed as a semi-automated tool which basically is used by operators.

A more complex integrated fill and sealing press tool is shown in Figure 10.9. This design is destined to be used as an integrated tool to vacuum the enclosed gimbal, refill (backfill) the interior space with helium, and afterwards seal the gimbal tight with a micro-precision ball.

The last of the tooling concepts attached, Figure 10.10, depicts the basic concept and machine design for the spinmotor robot assembly cell with emphasis on mounting arrangement and enclosure.

Existing tooling, which could be used by simply modifying sections of the tool, was used whenever feasible and recorded under "M" on the Tooling Requirements List, which stands for modified tooling. Other codes used include "N" for new tooling and "E" for existing tooling. Each of the tooling concepts was estimated for tool design and tool build, then these figures were used in the tooling requirements listings shown in Figures 10.11 through 10.14.

Figures 10.11 and 10.13 depict summary listings for tooling used in the GNAT and GG1111 product areas. Figures 10.12 and 10.14 show detail listings of tooling for the individual subassemblies/assemblies which are listed on the summary sheets. These listings were used for computing overall factory costs.

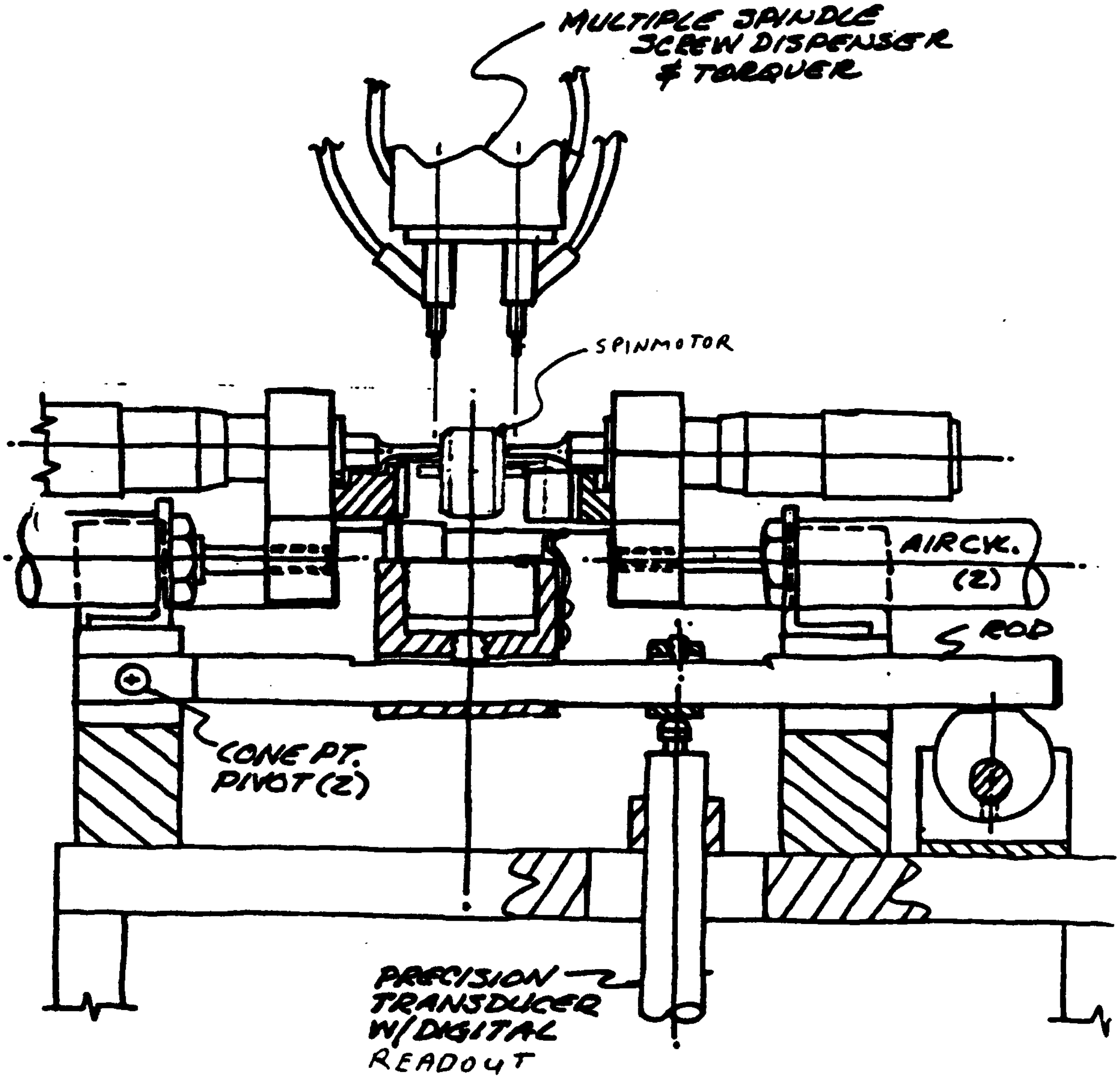


Figure 10.7. Pre-Balance and Holding Tool (Spinmotor Assembly GG1111 Spinmotor)

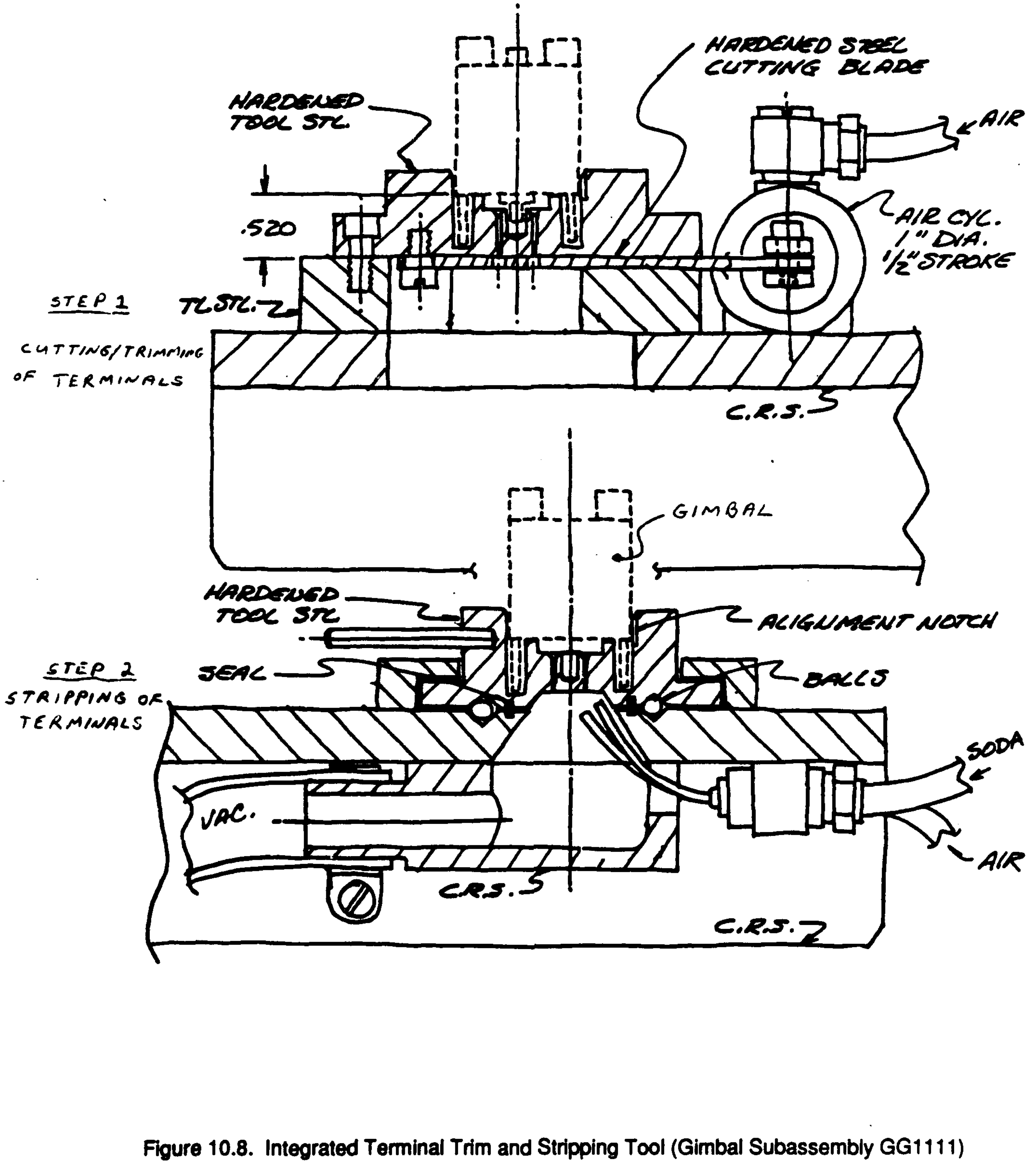


Figure 10.8. Integrated Terminal Trim and Stripping Tool (Gimbal Subassembly GG1111)

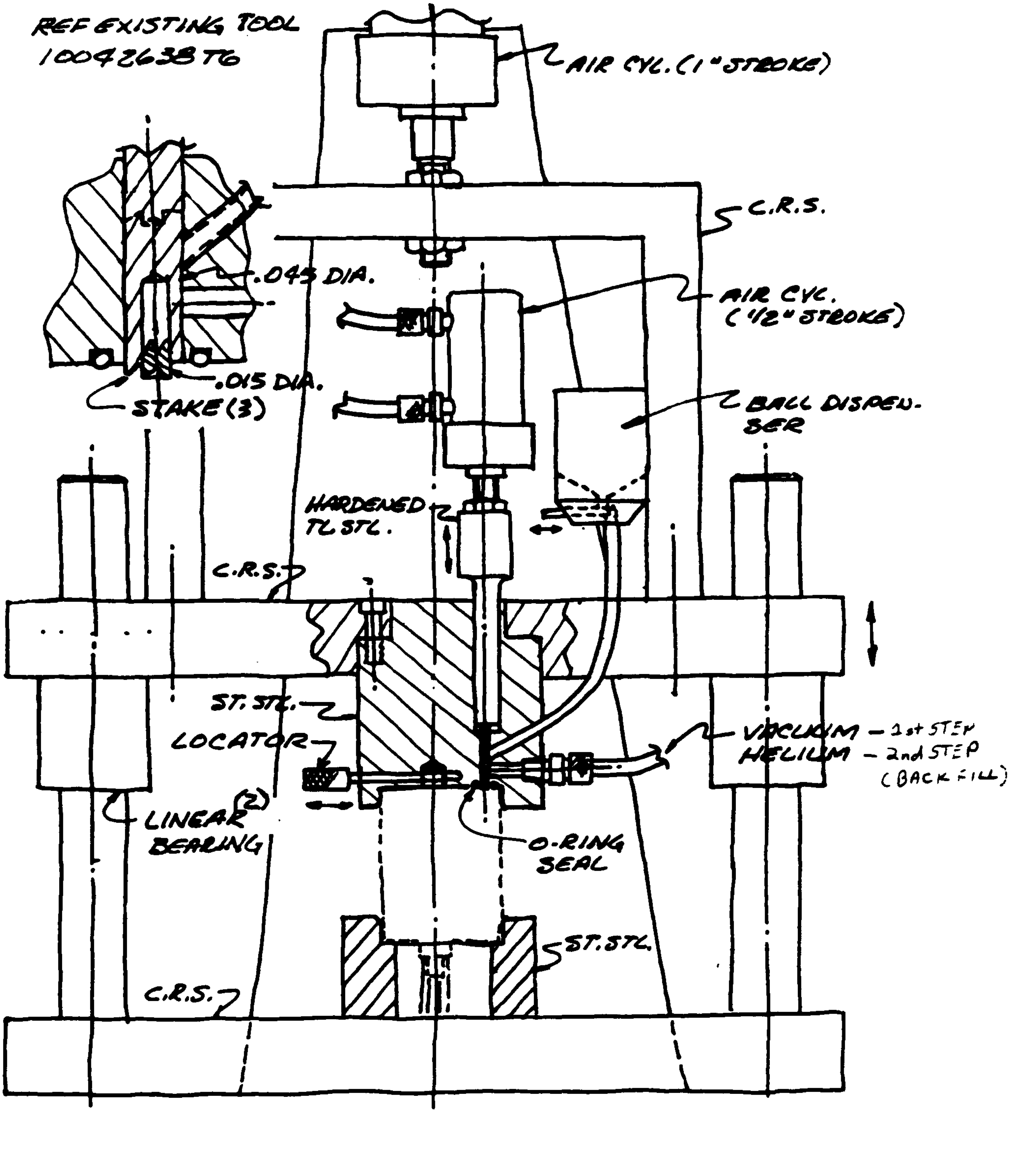


Figure 10.9. Integrated Fill and Sealing Press (Gimbal Subassembly GG1111)

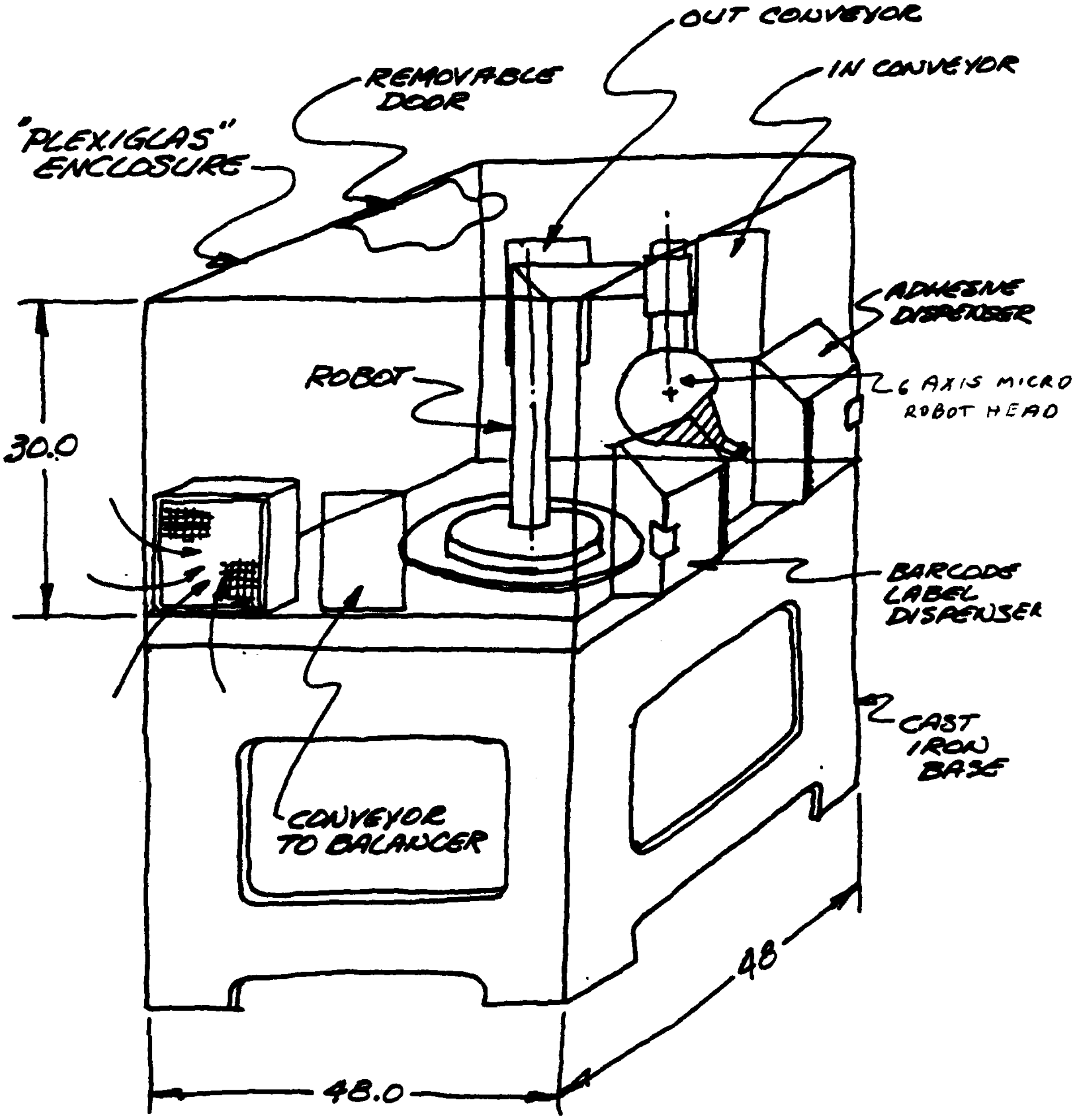


Figure 10.10. Mounting Stand and Enclosure for Spinmotor (Robot Assembly Cell GG1111/GG4400/GNAT)

TOOLING REQUIREMENTS SUMMARY

GNAT - GYRO ASSEMBLY LINE

#	TOOLING CODE ID	TOOLING CODE TOOL #	TOOLING CODE ISSUE	NEW	FOR OP #	DESCRIPTION	USED FOR PART #	QTY	VENDOR	LEADTIME (in hours)	TOTAL LEAD TIME	COST ($000)	ROM - ESTIMATES REMARKS
1				N		FINAL ASSEMBLY GNAT			FAB FAC	16	/	56.219	/
2						PICK OFF GIMBAL			FAB FAC	14	/	16.520	/
3						GIMBAL ASSEMBLY			FAB FAC	15	/	12.980	/
4	FARMED OUT					TORSION BAR			/	/	/	0.000	FAB FAC(44)
5	FARMED OUT					SLEEVE & ROTOR			/	/	/	0.000	FAB FAC(44)
6	BUILT IN GG		4400			MOTOR & HOUSING			SEE GG4400	/	/	0.000	COMMON ASSY
7	BUILT IN GG		4400			WHEEL ASSEMBLY			SEE GG4400	/	/	0.000	COMMON ASSY
8	FARMED OUT					ROTOR ASSEMBLY			/	/	/	0.000	FAB FAC(44)
9	FARMED OUT					HYSTERSIS RING			/	/	/	0.000	FAB FAC(44)
10	FARMED OUT					COATED LAMINATION			/	/	/	0.000	FAB FAC(44)
11	FARMED OUT					ROTOR			/	/	/	0.000	FAB FAC(44)
12	FARMED OUT					MOTOR STATOR			/	/	/	0.000	VENDOR
13	FARMED OUT					WALNUT			/	/	/	0.000	FAB FAC(44)
14						PICK OFF HOUSING			FAB FAC	12	/	12.940	/
15						STATOR P/O ASSEMBLY			FAB FAC		/	3.540	/
16						HOUSING & LEAD			FAB FAC		/	12.024	/
17	FARMED OUT					COMP ASSEMBLY (BELLOW)			/	/	/	0.000	VENDOR
18						THERMISTOR ASSEMBLY			FAB FAC		/	1.800	/
19						PADDLE ASSEMBLY			FAB FAC		/	8.000	/
20	FARMED OUT					PADDLE GIMBAL			/	/	/	0.000	VENDOR
						SUBTOTAL	($000)					124.023	
						+ 30% CONTINGENCY (PLOT,TRY OUT,MODIFY, REPLACE)						37.207	
						GRANDTOTAL	($000)					161.23	

10.11. Tooling Requirements Summary (GNAT Device)

TOOLING REQUIREMENTS DETAIL

GNAT - FINAL ASSEMBLY

#	TOOLING CODE ID	TOOL #	ISSUE	NEW	FOR OP #	DESCRIPTION	USED FOR PART #	QTY	VENDOR	LEADTIME (in hours)	TOTAL LEAD TIME	COST ($000)	ROM - ESTIMATES REMARKS
1	CA	T001	1	N	012A	HOLDING DEVICE FOR BALANCING OF GMAT-GYROS		1	S/FAB FAC	3 + 8	11	5.67	D=35,M=70
2	CA	T002	1	N	014A	CLEANING RACK FOR TABLE TOP-ULTRASONIC CLEANER		1	FAB FAC	1 + 4	5	0.594	D=3,M=8
3	CA	T003	1	N	023A	LOCATOR FOR SOLDERING PADDLE ASSY TO ASS.		2	FAB FAC	3 + 5	8	11.61	D=65,M=85
4	CA	T004	1	N	039A	INDUCTION COIL/HEATER INSERT(STATION SOW-020-101)		2	FAB FAC	2 + 4	6	0.81	D=3,M=6
5	CA	T005	1	N	055A	INDUCTION COIL/HEATER INSERT(SOLDER BELLOWS TO ASS)		2	FAB FAC	2 + 4	6	0.54	D=2,M=4
6	CA	T006	1	N	060A	HOLDING FIXTURE FOR GYRO LEAK TEST(VARIAN 936-60)		1	FAB FAC	4 + 7	11	2.08	D=15,M=23
7	CA	T007	1	N	069A/070A	PUMP DOWN & FILL FIXTURE FOR GMAT		4	FAB FAC	6 +10	16	16.2	D=40,M=65
8	CA	T008	1	N	085A	HOLDING/SOLDERING DEVICE FOR INDUCTION WELDER		1	FAB FAC	4 + 8	12	1.08	D=8,M=12
9	CA	T009	1	N	044A/024A	HOLDING FIXTURE FOR AUTOMATIC GAUGING PROCESS		2	FAB FAC	3 + 8	11	3.13	D=10,M=24
10	CA	T010	1	N	035A	HOLDING FIXTURE FOR SOLDERING STOP INSERTS		1	FAB FAC	3 + 8	11	2.16	D=12,M=28
11	CA	T011	1	N	192A	HOLDING FIXTURE FOR FRA-RATE TABLE		2	FAB FAC	4 + 9	13	5.4	D=20,M=60
12	GM	T165		N	085A	HOLDING FIXTURE FOR SEATING PLUG		1	FAB FAC	4 + 8	12	2.05	D=14,M=24
13		/		N	ALL	MISC. SMALL FIXTURES AND TOOLS (EST. ROM)		-	FAB FAC	/	16	4.5	/
						TOTAL						55.824	

Figure 10.12. Tooling Requirements Detail (GNAT Final Assembly)

TOOLING REQUIREMENTS SUMMARY

GG1111 - GYRO ASSEMBLY LINE

#	TOOLING CODE ID	TOOLING CODE TOOL #	TOOLING CODE ISSUE	NEW	FOR OP #	DESCRIPTION	USED FOR PART #	QTY	VENDOR	LEADTIME (in hours)	TOTAL LEAD TIME	COST ($000)	ROM - ESTIMATES REMARKS
1				N	/	FINAL ASSEMBLY GG1111			B + FAB FAC	15	/	126.100	
2				N	/	CABLE ASSEMBLY			FAB FAC	26	/	51.300	
3	FARMED OUT			/	/	PISTON & BELLOW ASSEMBLY			/	/	/	0.000	FAB FAC(44)
4	FARMED OUT			/	/	COVER & DISK			/	/	/	0.000	FARMED OUT
5	FARMED OUT			/	/	PLATE & BEARING			/	/	/	0.000	FAB FAC(44)
6				N	/	TORQUER SIGNAL GENERATOR			FAB FAC	14	/	14.100	
7				N	/	PRIMARY COILS			FAB FAC	14	/	10.700	
8				N	/	HEADER MAGNET SA			FAB FAC	15	/	11.700	
9				N	/	HEADER ASSEMBLY			TBD	8	/	0.350	
10	FARMED OUT			/	/	BASE MACHINED			/	/	/	0.000	FAB FAC(44)
11	FARMED OUT			/	/	FLUX RETAINER RING			/	/	/	0.000	FAB FAC(44)
12				N	/	GIMBALL MOTOR HSG.			FAB FAC	17	/	47.990	
13				N	/	BALL & INSERT ASSEMBLY			B + FAB FAC	18	/	20.240	
14				N	/	HOUSING & BALANCE PAN			FAB FAC	12	/	3.800	
15				N	/	BALANCE PAN			FAB FAC	9	/	0.650	
16	FARMED OUT			/	/	GIMBALL MOTOR END			/	/	/	0.000	FAB FAC(44)
17				/	/	HOUSING & BALL ASSEMBLY			/	/	/	0.000	
18	FARMED OUT			/	/	GIMBALL BAFFLE END			/	/	/	0.000	FAB FAC(44)
19				N	/	MOTOR AC - HYST.			FAB FAC	16	/	51.760	/
20	FARMED OUT			/	/	RING & LAMINATION HYST.			/	/	/	0.000	FAB FAC(44)
21				N	/	STATOR WIND ASSY			FAB FAC	13		14.560	
22				N	/	COIL ASSEMBLY TORQUER			FAB FAC	15		16.270	
23				N	/	BOBBIN COIL			/	/		0.000	
						SUBTOTAL	($000)					369.520	
						+ 30% CONTINGENCY (TRY OUT,DEBUG,MODIFY, REPLACE)						110.880	
						GRANDTOTAL	($000)					480.4	

Figure 10.13. Tooling Requirements Summary (GG1111 Device)

TOOLING REQUIREMENTS DETAIL

GG1111-MOTOR,AC-HYST.(SPIN MOTOR)

#	TOOLING CODE ID	TOOL #	ISSUE	NEW	FOR OP #	DESCRIPTION	USED FOR PART #	QTY	VENDOR	LEADTIME (in hours)	TOTAL LEAD TIME	COST ($000)	REMARKS
1	AS	T001	1	N	020A	BEARING POSITION CHECKER/CHANGER		1	FAB FAC	5 + 9	14	3.000	D=20,M=35
2	AS	T002	1	N	020A	ASSEMBLY FIXTURE (FOR MOTOR ASSY)		1	FAB FAC	5 + 9	14	3.540	D=25,M=40
3	AS	T003	1	N	020A	SLEEVE REMOVAL TOOL (FOR WOUND STATOR)		1	FAB FAC	5 + 8	13	3.830	D=25,M=45
4	AS	T004	1	N	020A	LEAD WIRE STRAIGHTENING TOOL(WOUND STATOR)		1	FAB FAC	5 + 8	13	3.560	D=20,M=45
5	AS	T005	1	N	020A	MOTOR CRADLE FOR LASER BALANCER		1	FAB FAC	4 + 8	12	2.980	D=20,M=35
6	AS	T006	1	N	020A	BEARING PRELOAD FIXTURE		1	FAB FAC	5 + 9	14	3.560	D=25,M=40
7	AS	T007	1	N	020A	ROBOT END EFFECTER MODIFICATION (FOR BRG.)		1	FAB FAC	4 + 8	12	2.970	D=20,M=35
8	AS	T008	1	N	020A	ROBOT CELL ENCLOSURE & BASE		1	FAB FAC	6 + 10	16	28.320	D=120,M=165
9													
10													
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													
						TOTAL	($000)					51.760	

Figure 10.14. Tooling Requirements Detail (GG1111/Motor AC Hysteresis-Spinmotor)

SECTION 11

VENDOR/INDUSTRY ANALYSIS FINDINGS

The project team was challenged to locate suppliers which could meet the technical specifications generated by the multitude of diverse and complex pieces of precision equipment identified for the new PCI factory. Instead of identifying a single, capable turnkey implementer, the 51/52 project team had to locate a number of companies as suppliers for the equipment. The suppliers varied in size and were located around the world.

In addition, a survey was conducted to identify a system implementer for a computer control system which would integrate and control the numerous complex manufacturing tasks of the "To-Be" factory, thereby leading to the "Paperless Factory" concept as stated in the factory specifications. The computer control system has been described in Section 13 of this report.

Industry surveys identifying suppliers of relatively low-value and/or high-specialization equipment were generally of limited value for this project. Consequently, additional effort, equal in time and intensity to the initial literature review, was required to find the right suppliers.

The search for equipment was based on selected machinery and systems which was called out on the individual "To-Be" process layouts and specified on equipment specification sheets. With the aid of the equipment codes (Figure 9.1), the pieces of equipment could easily be traced back to its original application on the process layout, and subsequently to a particular process and operatior.. Equipment requirements listings as shown on Figure 9.5 have been developed as a result of those documents, and have exclusively been used as the primary link for placing and locating individual pieces of equipment on floor layouts.

Equipment was divided into the following groups in order to perform the search for suppliers:

- Small/low-value equipment and tools
- Standard/competitive equipment
- Specialized equipment
- Highly specialized/tailored equipment
- Computer systems/controls.

As might be expected, the last two groups proved to be the critical ones and required great effort and time to find the supplier with precisely the equipment or systems specified.

SMALL/LOW-VALUE EQUIPMENT AND TOOLS

This group primarily addressed table top equipment and tools (e.g., table top degreasers, miniature torquer wrenches and power tools, wire strippers, cuters and forming devices, small table top equipment and other equipment for supporting manual operations). The search generally was limited to equipment catalogues of well known and selected companies. Equipment and vendors for this group basically were selected on the following criteria and priorities:

- Does equipment meet design requirements and specifications?
- Is the equipment vendor known to Honeywell?
- Does equipment size meet expectations? Will it easily fit on workstation set-ups?
- Is equipment available?
- Does equipment meet price expectations?
- What is the appearance/features of the equipment?
- Is the equipment ergonomically designed?

Prices for low-value items were primarily taken from catalogues and were reconfirmed over the telephone in some instances.

STANDARD/COMPETITIVE EQUIPMENT

Suppliers for standard/competitive equipment were selected based on written quotations fc items over $5,000 while quotations given over the phone were acceptable for selecting equipment of less value. The following equipment generally was considered standard equipment.

- Workstations/workbenches
- General shop furniture
- Barcode readers/electronic decoders
- Single conveyors
- Ovens/chambers/freezers
- Standalone cleaners
- Barcode marking/printing devices

- Vertical storage and retrieval systems (VS/RS)
- Microscope with CRT-scope

Bids on workstations/workbenches were received from three potential suppliers: Wilfab, Herman Miller, and Staether. The quotations from Wilfab were most complete and the company responded to inquiries by inviting team members to see their exhibition on workstations in the Twin Cities. Miller's and Staether's response was received over the phone and through mailed literature. Since choosing workstations for new factories is strongly influenced by personal likes and dislikes, especially when all bidders met all specifications, the project team finally decided to use the mean of the three bids for computation of factory costs while leaving selection to the end user. It was proposed to make a final decision prior to the implementation, based on a trial of the quoted units.

Quotations for general shop furniture and office furniture were received from Honeywell's Procurement department which has accounts with one of the local suppliers.

Quotations for barcode readers were requested from York, Percon, E. A. Schultz (a local supplier of readers and labelers), and Honeywell procurement. A company called Zebra was contacted for pricing barcode label printers. Since Honeywell MAvD currently is implementing a factory data collection system (FDC) under a separate project, which also is using barcode identification equipment, a decision was made to use the figures as considered for FDC. E. A. Schultz was chosen for the barcode labelers based on price and features of the unit. Zebra was chosen based on the price for generic barcode printers.

It is important to note that, as previously mentioned, all equipment with short lead times will have to be requoted prior to the implementation of the Tech Mod program, Phase III, due to program schedules which exceed quoted periods on equipment.

Two companies, Jergens and Weldun Automation, were quoted on conveyors which would be used for material handling of parts and assemblies and as pacing systems for the assemblies. Representatives of each company were presented with marked up facility layouts and conveyor specifications which then were used as the basis for their quotations. Unfortunately, neither bid was satisfactory and could not be considered as a final quotation for implementation. Weldun Automation's material handling/conveyor system did not meet the price expectations and their bulky design would have required redesigning sections of the floor layouts in order to fit it in. Jergen's conveyor specifications met the needs of the factory design, but their quotes were incomplete and were used only for factory cost calculations. Consequently, conveyors will have to be requoted prior to Phase III implementation.

Ovens, freezers, and cleaners are items which currently are used in all four product areas. These items already have established, historical vendors of record. Therefore, the project team either used known surplus equipment or used data and prices from previous purchases for finalizing factory costs.

Vertical storage and retrieval systems (VS/RS), which would meet size requirements for the new factory, were quoted by Raymond and White. After getting involved with selecting and contacting these two and other firms (e.g., Spacesaver, Kardex), it was learned that none of the companies could supply the smaller sizes of VS/RS's needed for the buffer areas. Based on this new information, the team finally decided to change the design and move to a less advanced material storage system. The quotations received for the remaining larger VS/RS's were within our expectations, and since White's VS/RS's have been used at several locations in Honeywell with excellent results, White was selected as the supplier for the remaining VS/RS's.

Olympus was chosen as the supplier of microscopes with CRT's as they were called out for the subassembly and final assembly areas for selected workstations. This decision was based on the reputation Olympus has in the business for the price and quality of its products.

SPECIALIZED EQUIPMENT

Specialized equipment suppliers were asked to supply information on the following.

- Automated guided vehicles
- Injection molding equipment
- Mini-assembly robots
- Special test and measuring equipment
- Pneumatic tube handling systems
- Laser markers
- Temperature chambers
- CNC - Winding equipment
- CNC - Laser balancers
- Temperature cycling ovens
- Leak detection equipment
- Computerized continuity and Dielectric tester
- CNC - Notching/milling equipment

The choice for AGVS's was limited to one supplier: Litton, New Zealand, Michigan. The other suppliers considered could not deliver small size systems with two foot wide carriers nor could they provide a high enough level of automation for delivery and pickup of material. The other suppliers also did not offer a guide-path which was 1) non-destructive of cleanroom, office, and/or electronic assembly area floors, and 2) easily changed if so required. In contrast, Litton's AGVS's met the requirements for operating the system within a cleanroom.

Technical requirements included injection molding equipment with a special vertical upright design. Such equipment currently is used in the cable and coil assembly torquer cells of the GG1111 factory. Consequently, the team was limited to choosing between two potential suppliers: Gluco and Morgan Press. In the final selection process, Gluco was chosen because the company could meet the technical requirements, had a superior design, and met stated price expectations.

Two types of robots are planned for the new factory. One is a general, less accurate, robust four to six axis robot which has been identified as a cleaning robot for parts which would be located in each of the three buffer areas (GG1111, GG4400/GNAT and Packages). These robots are exclusively used for cleaning of small parts and material prior to the kitting process in the buffer prep area. One of three robots can be seen on the GG1111 floor layout (Figure 8.22) adjacent to the buffer clean room and material prep area.

The second robot is a highly specialized and accurate small, six to nine axis micro-robot, which is used in micro electronics and small parts assembly. Two of these micro robots have been identified for the unmanned assembly of spin motors in the GG1111 and GG4400/GNAT spin motor assembly cells (see Figure 8.22).

Two suppliers were identified for submitting quotations on pneumatic tube systems. These systems are known from drive-through banking used for transporting checks to tellers, now they are more and more introduced into small parts handling in industry. These systems are highly effective, fast, and convenient inner plant material handling systems slated for use in the new factory. Typically, small parts travel in well cushioned containers within the various input and output stations within the assembly lines. Three and four inch tube sizes were chosen for the four assembly lines. The local supplier, SPCI, was chosen over Trans Logic based on price, simplicity and effectiveness of the system, and good references in the Twin Cities where the system is used in banks, hospitals, and smaller companies.

The search for a feasible laser marking system led to the Lumonics product, which was first spotted at the 1987 Westcon in Los Angeles. The Lumonics laser marker was finally selected as the standard laser marker for the laser marking tasks (e.g., nameplates, parts marking, etc.) in the buffers of each of the four assembly lines (total of 3 markers). The criteria for selecting Lumonics product was small size, compactness, and a favorable lower price (which was the determining factor in decision making).

After searching for a potential supplier of computerized temperature test chambers with flow through design to accommodate the paced assembly lines, the project team learned that such designs are possible but are not available as shelf-type units. One supplier, Ransco, finally was willing to provide a quotation based on the purchase of several units in order to distribute design and development related costs more favorably. The application and use of these temperature test chambers is called out in the equipment requirements listing of each of the four assembly lines. The quoted price has been used for factory cost calculations but has to be requoted prior to finalizing the purchase of these units.

After checking several domestic and international suppliers of coil winding equipment, the project team finally asked the supplier Meteor to submit a quote. CNC coil winders are primarily used at the header and coil assembly torquer cell of the GG1111 assembly (see respective equipment requirements listings). Meteor was able not only to meet the technical specifications but also could meet requirements for automation and machine set-up initiated via bar code identifier. Also, Honeywell is familiar with Meteor equipment and Meteor personnel were familiar with Honeywell products and practices.

Schenck AG, a well known manufacturer for computerized and automated spinmotor laser balancing equipment, was chosen to continue supplying computerized and automated spinmotor laser balancing equipment to PCI.

The choice for leak detection devices focussed on two suppliers, Varian and Veeco, whose equipment has been used in the current factory. Quotes which recently had been requested by the Production Engineering department for other reasons were used in the factory cost computation for individual product areas.

Fluke, through a local representative, provided quotations on computerized and dielectric testers. These testers were anticipated for use at several workstations along the assembly lines for the new factory. Once again, this equipment was not available as shelf-type units and would require some development efforts by Fluke. The company submitted quotations on the basis of stacked unit quantities and price. The price used for the factory cost calculations is based on a quantity of twelve units.

The highly specialized and miniaturized CNC-notcher for the GG1111 final assembly line was identified as product used in the model making industry manufactured by Servo-Products Company in California. Since no other suppliers could be located which were able to provide a mini-CNC milling machine, the team finally selected the Servo-Products Co. as the supplier.

HIGHLY SPECIALIZED/TAILORED EQUIPMENT

Highly specialized/tailored equipment suppliers also were contacted by the team. Examples of equipment in this category include:

- Automated test equipment (ATE) for complex/specialized testing including functional tests.
- Four pole magnet charger for header subassembly line.
- Integrated machining cell for gimbal (GG1111).
- High speed sensor fill station.

- Automatic balancer for sensors.
- Computerized motor-run-in cell.
- Machining and boring cell for header.
- Other smaller specialized equipment.

Automated test equipment, which is used in all of the four product areas, comprises the bulk of the capital expenditures for the new factory. With few exceptions, the required ATE capital is proposed for enhancing existing test stations to the level outlined in the "To-Be" process versus procuring new equipment. Current test stations were designed and manufactured by TSLO, the internal Honeywell manufacturer of such equipment. The decision to request cost estimates from TSLO for these stations was not only corporate policy but was a logical decision. Figure 11.1 depicts an example of a cost estimate for an acceptance test station (ATP-Test) which is typical for the complexity of other stations. Cost estimates and/or quotations were prepared at cost for TSLO. Automatic balancers and the motor run-in-station were also quoted by TSLO.

F W Bell Inc. was selected for supplying a four pole automatic magnet charger as it was identified for the GG1111-Header subassembly line. Since this is highly specialized equipment, the team did not search for another supplier or quote.

The integrated machining cell identified for gimbal assembly machining combines five operations into one. It is a mini-table top, highly automated, specialized machine for which no capable suppliers could be found due to the time and resource constraints. To obtain reasonable prices, the team was forced to request quotes for comparable CNC-Universal equipment which could perform the same work. The implementation team will be required to find a capable supplier for this piece of equipment and to determine a reasonable price.

New high speed sensor fill stations, which were a spinoff of a special analysis during the Tech Mod Phase II study, were proposed for the filling processes of the sensors GG1111, GG4400, and GNAT. The new design requires that first the new process must be developed, refined, and then translated into a reliable fill station. Since this is one of the most critical processes in the final assembly of a sensor, it is imperative that PCI engineers and technicians in a particular product group are actively involved during the development and build cycle of the fill station. Due to this fact, the team decided to have this station manufactured by development laboratories in IIO and Fab Fac.

The machining and boring cell for headers is of similar design as the previously described machining cell for the gimbal and has been quoted and priced identically. Again, a capable builder of special equipment must be found to develop this mini-table top machine as defined in the "To-Be" process.

Other smaller specialized equipment has been quoted item by item in order to gain a realistic and usable base for calculating factory costs. The final selection of vendors for this equipment, at a date prior to the implementation in Phase III, must be based on new equipment quotes and the criteria described above.

COMPUTER SYSTEMS/CONTROLS

Section 13 describes the approach, analysis, and selection of Honeywell's Industrial Automation Systems Division in Phoenix as the supplier of the integrated computer system selected for the "To-Be" factory.

ROM COST ESTIMATE FOR ACCEPTANCE TESTER (ATP)
(FOR GG1111 FINAL ASSEMBLY LINE)

• CONDITIONS AND ASSUMPTIONS:

1) The resulting station will include the measurement capability of the noise test station (ROM cost estimate of Item #2) in addition to the requested enhancements described below.

2) ATP test software will reside on the station's hard disk and be called up and executed as a result of a barcode scan.

3) Exitation and loads (if needed) will be automatically set up and verified prior to connection to the ATP.

4) A printer will be available for local hard copy of intermediate and/or final test data.

5) Test results can be electronically sent to a larger computer system.

6) Existing ATP holding fixtures will be used.

7) This composite station will contain a single computer.

NOTE:
- ACCEPTANCE TESTING - ATP
- USES EXISTING GG1111 F500-1 MANUAL STATION
- LAYOUT REFERENCED - NONE.

Figure 11.1. Example of Equipment Cost Estimate

- <u>PURCHASED COMMERCIAL ITEMS:</u>

  1 - Relay Rack with blower and table
  1 - TEIC Scope
  1 - 2 Axis Radial Positioning System w/ I/F
  1 - Contraves 1-Axis Rate Table w/RS232 I/F
  1 - Fluke 8842A DMM
  1 - Keithly 194 DVM
  1 - HP3561A Signal Analyzer
  1 - North Atlantic 2250A DPAV
  2 - STD Card Cage
  STD Plug in cards:
  4 - switch matrix
  1 - power control
  1 - counter/timer

  1 - 10 programmable AC power source (SIG Gen)
  1 - 20, 30 programmable AC power source (spn mtr)
  1 - Station DC power supply chassis
  1 - Honeywell AP computer

  1.2 MB floppy, 30 MB hard disk, 60 MB cartridge tape,
  640 K RAM, 2 serial, 1 parallel . . . . . .

  Keyboard, CRT, Graphics controller
  Numeric co-processor
  Dot matrix printer
  Bar code reader
  Communications I/F to Work Center Manager
  IEEE - 488 I/F
  Ultra link I/F cards

Purchased S/W
  DOS
  Languages
  Communication

Figure 11.1 Example of Equipment Cost Estimate (Continued)

• <u>HONEYWELL DESIGNED/BUILT ITEMS</u>:

1 - Servo Amp
1 - Resistor load
1 - Capacitor load

1 - J-Box
Design Eng.
Tool Design
FAB FAC
TEP Build
Prod. Asm.
Material

10 interconnecting cables and cable I/F panel

• <u>HONEYWELL DESIGNED SOFTWARE</u>:

IEEE 488 Instruments
2 - Axis positioner
Fluke DMM
Keithly DVM
HP Signal Analyzer
Programmable AC
North Atlantic OPAV

Rate table
Switch matrix
Power control
Resistor/capacitor loads
Servo Amp.

ATP Test S/W
Test Director
Work Center I/F

Figure 11.1. Example of Equipment Cost Estimate (Continued)

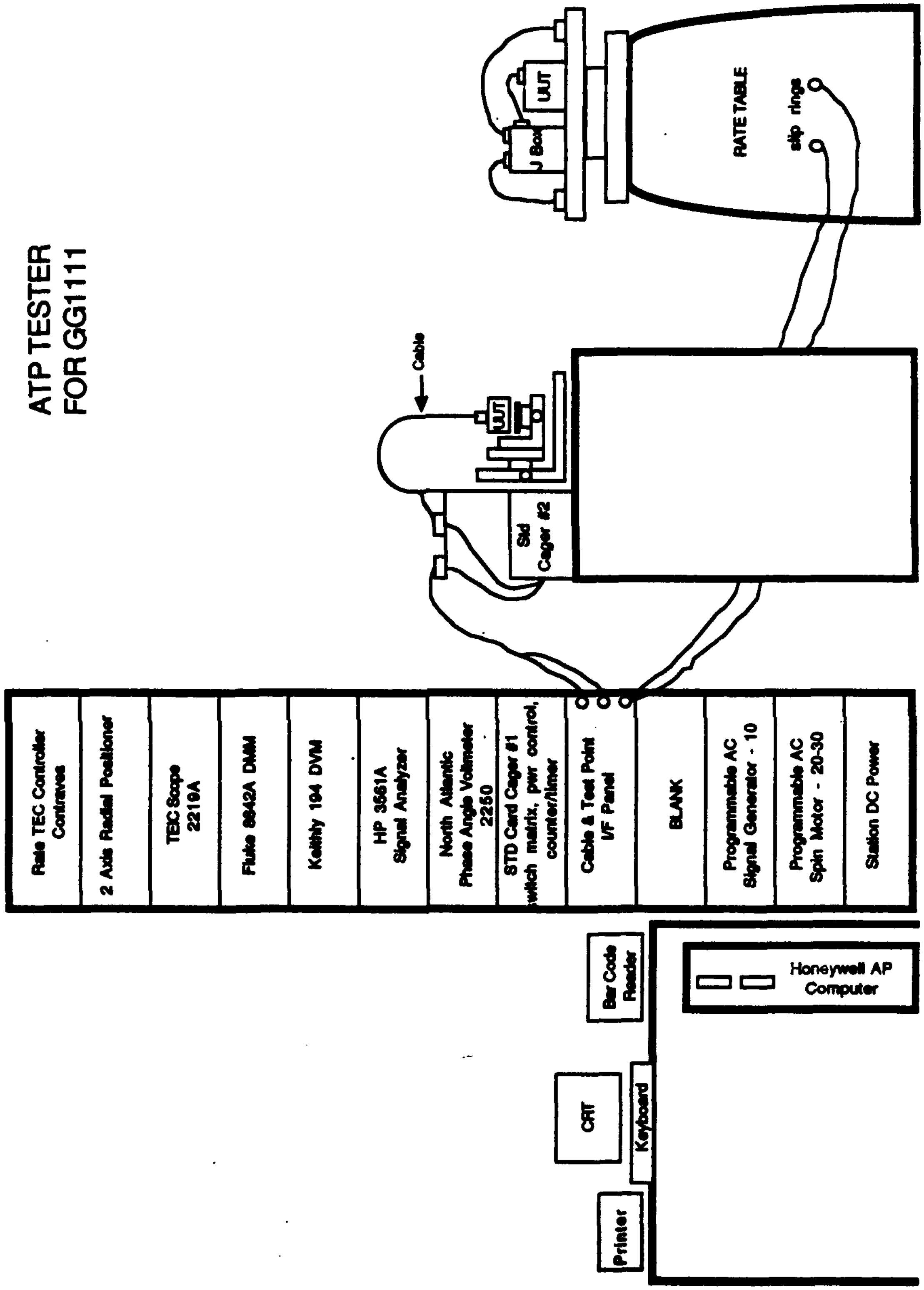


Figure 11.1. Example of Equipment Cost Estimate (Continued)

SECTION 12

EQUIPMENT/MACHINERY ALTERNATIVES

Changes of equipment specifications, which might require alternate equipment and could influence the level of modernization of the new factory, are less critical in Project 51/52 than in other projects of this nature. The reason is the high number of diversified equipment which has been used in the new design. As a whole, the equipment might influence final results on a bigger scale but each individual piece of equipment has less impact.

With few exceptions, the equipment/machinery which has been identified for the "To-Be" factory is state-of-the-art equipment and shelf-type items. Both generally can be procured with short lead times.

Due to the complexity of processes, which can be found in all four product areas, many of the new "To-Be" processes remained manual operations. Therefore, individual equipment and machinery has less impact on the overall result than is true for more highly automated factories.

To judge the effect of using alternate equipment for sections of the new factory, the design team used the equipment breakdown which was shown in Section 11. This breakdown served as a base for weighing the criticality of using and finding alternate equipment and machinery. The equipment breakdown is listed below for easy reference.

- Small/low-value equipment and tools
- Standard/competitive equipment
- Specialized equipment
- Highly specialized/tailored equipment
- Computer systems/controls

SMALL/LOW-VALUE EQUIPMENT AND TOOLS

Small equipment and tooling have almost no impact on alternate equipment concerns. The influence of changing over to a different brand or slightly different design is so minimal that it can be neglected. On the supply side, it is very easy to find alternate suppliers which are eager to offer their product. As long as technical specifications can be met by another supplier, it is fairly safe to switch to a different supplier.

STANDARD/COMPETITIVE EQUIPMENT

In using standard/competitive equipment, changing to alternate equipment also results in little or no impact on the overall "To-Be" factory. Most of the equipment is plain standard equipment which can be procured from a number of suppliers and is comparable in function and appearance. This second group contains equipment such as modular workbenches, ovens, conveyors, VS/RS's, ultrasonic cleaners, and others as listed in Section 11.

SPECIALIZED EQUIPMENT

Robots, AGVS's, and injection molding equipment are representative of the specialized equipment. This equipment group affects the design of the new factory more than the previous groups affect it. Changing to alternate sourcing or revised designs could adversely impact the new factory. The equipment is more specialized and therefore is offered by fewer suppliers. However, the equipment is still generally easy to procure. The survey conducted by the team showed that it is relatively easy to find various suppliers with alternate equipment. In some cases this will mean changing the technical specifications.

HIGHLY SPECIALIZED/TAILORED EQUIPMENT

The impact of alternate equipment is greatest on highly specialized/tailored equipment. This equipment group contains ATE's, integrated machining cells, automated magnet chargers, high speed sensor fill stations, automatic balancers, computerized spin motor run-in cells, and other high technology equipment and machinery. The major concern with this group is not to get a piece of machinery that will meet the technical specifications, but rather to find a competent equipment supplier which is capable of building a reliable and reasonably priced piece of hardware.

In the case of the ATE's, this could mean changing to a less sophisticated tester which would require more time to operate. This in turn would influence how many testers would need to be used to meet product flow in a timely manner. The team is confident that TSLO, as the chosen supplier for ATE's, is not only capable of meeting the technical specifications (based on their track record) and lead times (as outlined in their quotes) but actually will surpass the outlined specifications due to their knowledge. In the case of mechanized equipment, the main task remains locating the manufacturer which is most qualified to make reliable equipment as specified.

Since all product areas use only a few special integrated machining cells of known technology, the equipment can be built to the required specifications without requiring alternate designs. In summary, even though the equipment is highly specialized, the team believes that alternate equipment will not be required since locating the most qualified manufacturers circumvents any need to alter designs.

COMPUTER SYSTEMS/CONTROLS

The computer systems and controls group is the most sensitive to alterations in equipment or systems. Since the system for the new factory has been specified as an integrated CIM-related control and planning system, many changes can be expected over the course of its development in Phase III (or before). This state of change is the mode throughout the entire industry. Consequently, changes or modifications must be dealt with one at a time and/or as they occur.

The most critical issue becomes locating a reputable system integrator. This issue was resolved by the decision to use Honeywell's Industrial Automation Systems Division (IASD) in Phoenix. Since the system proposed by IASD is in the process of being piloted in Honeywell's Clearwater Division under another Tech Mod program, the team is confident that some initial problems will be resolved prior to installing/tailoring the system to IIO/PCI needs.

SECTION 13

MANAGEMENT INFORMATION SYSTEMS (MIS)

REQUIREMENTS/IMPROVEMENTS

INTRODUCTION

To fully benefit from the Modernization Program, the Tech Mod team found it necessary to adopt a "Paperless Factory" concept as a long range goal, starting with the implementation of the 51/52 Modernization Program.

At the same time that Phase II was in process, Honeywell MAvD had a plan in place for an immediate implementation of a new MRPII system, the Honeywell Manufacturing System (HMS). In studying the system, the team learned that this was of limited use for control and planning functions of the four assembly lines. HMS could not be used in controlling the line pacing, nor could it be used for the short scheduling windows and the required data communication and recording functions within each work center. HMS is a master scheduling system with weekly/monthly planning windows and not designed for applications as required for the four assembly lines. It was essential to find a system which could be interfaced with HMS and would communicate on this level, but primarily would meet the requirements of the lines for daily and hourly scheduling windows and pacing capabilities in fractions of an hour. The lines needed micro computers which also could handle a great amount of data and collect/distribute those in real time within the various workcells and control points.

This lead to a search for an efficient but reasonable computer system with excellent interfacing capabilities, high speed computing power and at a later date could still be expanded and enhanced. The Work Center Manager (WCM), a new product of Honeywell's Industrial Automation Systems Division (IASD) in Phoenix was finally chosen to fill this gap.

HONEYWELL MANUFACTURING SYSTEM (HMS)

HMS is a modular system comprised of the following modules.

- Master Production Scheduling (MPS)
- Inventory Records Management (IRM)
- Manufacturing Data Control (MDC)

- Material Requirements Planning (MRP)
- Capacity Requirements Planning (CRP)
- Purchase Material Control (PMC)
- Production Cost Accounting (PCA)

In addition to HMS, Honeywell also is implementing a process layout system which includes the Process Master System (PMS) and the Factory Data Collection system (FDC).

Phase I studies concluded that these systems, when fully implemented, would meet the MIS requirements for the project. However, Phase II studies of the new MIS systems concluded that they were inadequate in some areas:

- Data storage and retrieval capability was inadequate.
- CRP was not designed for a repetitive manufacturing environment.
- PMS included process summary information only; no process detail was available.
- Extensive revisions/additions would be necessary to meet the "Paperless Factory" concept

WORK CENTER MANAGER (WCM)

WCM - Introduction

A study was initiated by the project team to define the specifications necessary to meet the project's MIS requirements. The systems reviewed included General Electric's "Quality Information System" (QIS), "Computervision Factory Vision" (Project 32 FSO), and the Work Center Manager System (WCM). The latter is being developed jointly under a Tech Mod program by Honeywell's Space and Strategic Avionics Division (SSAvD) in Florida and the Industrial Automation Systems Division in Phoenix.

The WCM system addresses all of the needs identified by the Tech Mod team for Project 51/52. The WCM is being piloted in SSAvD and developed in an environment that is nearly identical to PCI in that it is an inertial sensor facility engaged in the production of military hardware. The WCM also is being developed to interface with HMS which is up and running at SSAvD. A pilot demonstration is scheduled for October 1987. The WCM development schedule fits very well with Project 51/52's implementation plan.

WCM applications include:

- Electronic scanning of existing documents.

- Central storage of documentation.
- Creation, revision, and control of shop data (graphics/text).
- Display of Operator/Inspector work instructions.
- Management of build history.
- Discrepant material tracking.
- Scheduling and dispatching.
- Manpower management.

The project team concluded that the WCM under current development by the Industrial Automation Systems Division (IASD), together with HMS and FDC, will meet all of the MIS requirements for Project 51/52. The WCM also will provide a system that will meet Honeywell and Department of Defense requirements for the next ten to fifteen years.

WCM - Background

At this time there is no turnkey product that fully meets the requirement to eliminate the flow of paper to and from the factory floor. Islands of technology exist, but a fully integrated solution does not exist today to bridge the "wall" between engineering and production. Honeywell has committed to the integration of the diverse technologies existing today into a full solution applicable to all manufacturers. This integrated solution is the "Paperless Factory", and is the philosophy and direction of Honeywell's Shop Floor Control and Factory Automation efforts. The heart of this "Paperless Factory", and the base from which all development will grow , is the Work Center Manager (WCM).

The "Paperless Factory" requirement was recognized by the Department of Defense's Industry Task Force on Computer Aided Logistic Support (CALS) in their recommendation to achieve major improvements in weapon system design; and to improve the accuracy, timeliness, and use of logistic technical information. To effect these improvements, on September 24, 1985, the Deputy Secretary of Defense approved a strategy for "transitioning from our current paper-intensive weapon system support processes to a largely automated and integrated mode of operation with substantial progress by the end of this decade". It is his goal that "the Department of Defense (DOD) will require DOD contractors to be able to acquire, process, and use logistic technical information in digital form. Insofar as possible, this shall be accomplished for new major weapon systems entering production in 1990 and beyond. Major weapon system new starts, development, and modification programs should begin to develop this acquisition strategy immediately".

The development of the "Paperless Factory" is aimed at the removal, or the significant reduction, of the amount of paper required to transmit and collect information to and from the factory. The control of information transfer electronically is IASD's solution to this problem.

Studies by Aerospace and Defense companies have indicated that a cost savings of 30-35 percent can be expected through such a solution. The benefits resulting from this solution will include:

- Reduced production lead time.
- Enhanced transition from Design to Production.
- Decreased labor costs related to process definition and maintenance, other paperwork generation and maintenance specifically related to the product build history.
- Improved production response.
- Improved internal communications.
- Enhanced ability to standardize common processes and procedures.

WCM - System Overview

The WCM is among the first in a family of products being developed by the Industrial Automation Systems Division to serve the factory needs of manufacturing companies. This Honeywell family is diversifying as it grows. Ultimately, it will provide a specialized solution to the major functions in the realm of distributed manufacturing planning and control.

Honeywell's WCM fills a crucial gap between plant management and factory floor operations, between the corporate computer and the workstation - a gap previously spanned only by a bridge of paper.

The software products platform is a super-micro computer based on the industry standard Motorola 68020 processor. The factory-developed 32-bit processor operates at 3.5 MIPS (millions of instructions per second) and is designed for easy expansion/ cost-effective growth.

The backbone of the Work Center Manager system is the communication network, which provides full network and terminal resiliency. All of the systems will be connected by high speed local area networks that have a maximum transfer rate of 10 million bits/sec. These local area networks support the industry standard network protocols.

The WCM implementation for Aerospace and Defense will allow the elimination or significant reduction of hard copy paperwork on the factory floor through:

- Electronic scanning of all existing documentation
- Central storage of all documentation
- Creation, revision, and control of text and graphic work instruction
- Interface into CAD Data Bases

- Display of operator work instructions and data collection forms. Statuses of all material in the build process is kept up to date in real-time by the WCM system.

- Management of Build History

- Discrepant Material tracking

- Scheduling and dispatching

- Manpower management.

The concept of the WCM development is to provide a smooth transition from the current environment "As-Is" to the future environment "To-Be". See Figures 13.1 and 13.2.

WCM - Factory Scheduling

The Work Center Manager is a decision support product designed to provide timely, accurate data collection, plus decision support capabilities for the supervisor.

The WCM provides advanced control of production and resources on the factory floor. In a typical application, the WCM production system:

- Receives orders from a parent MRP system as well as from local terminals;

- Generates detailed short interval production schedules;

- Maintains precise order, manufacturing process, and scheduling information;

- Dispatches and expedites orders;

- Tracks all work-in-process and generates current production data;

- Provides documentation management for all production process definitions.

WCM - Human Resource Management

The WCM supports a local human resource data base which identifies all employees in the area. The system will provide for the local maintenance of the data. This data base is capable of being loaded and revised by information supplied by the Plant level human resource system.

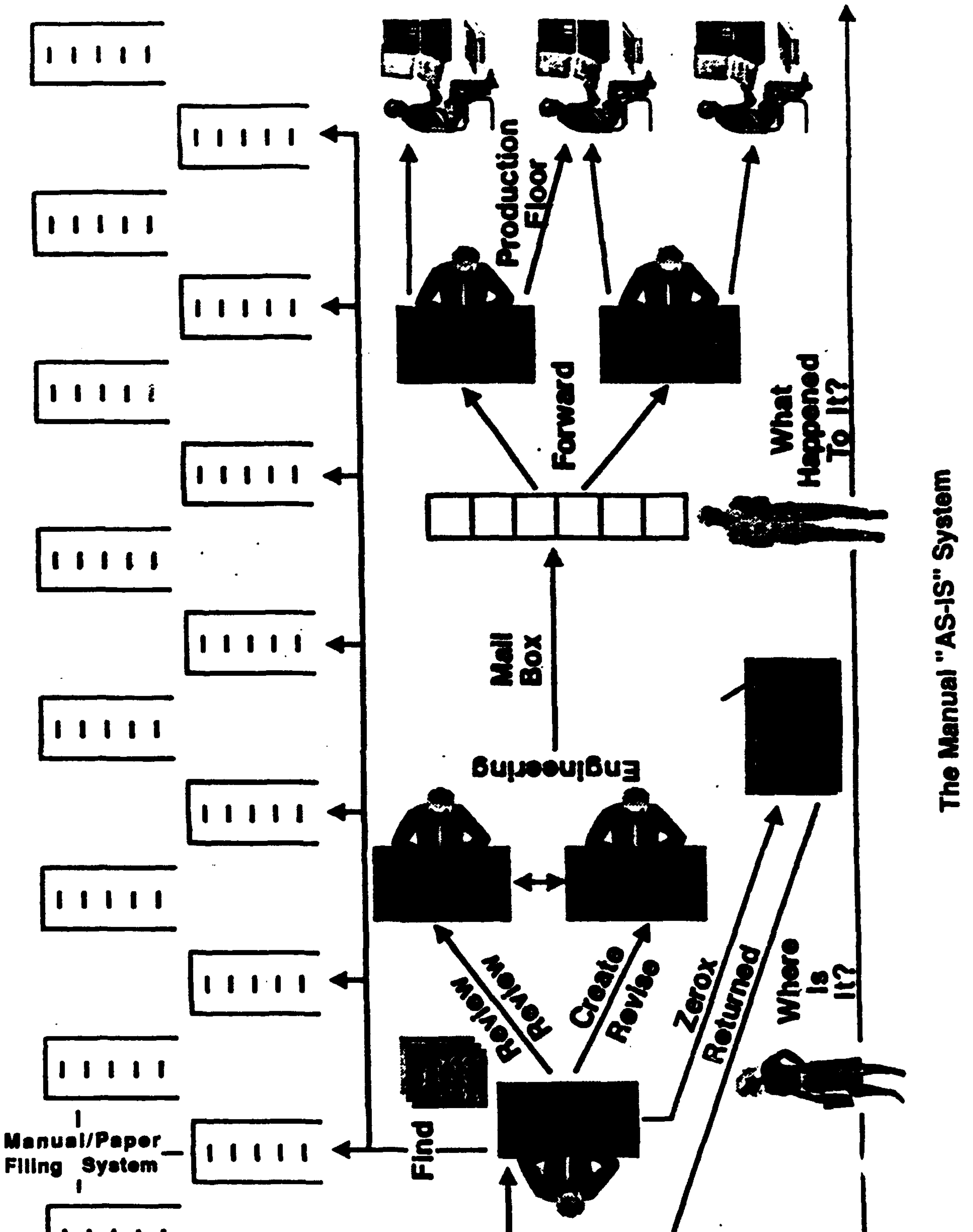


Figure 13.1. "As-Is" Manual Planning System

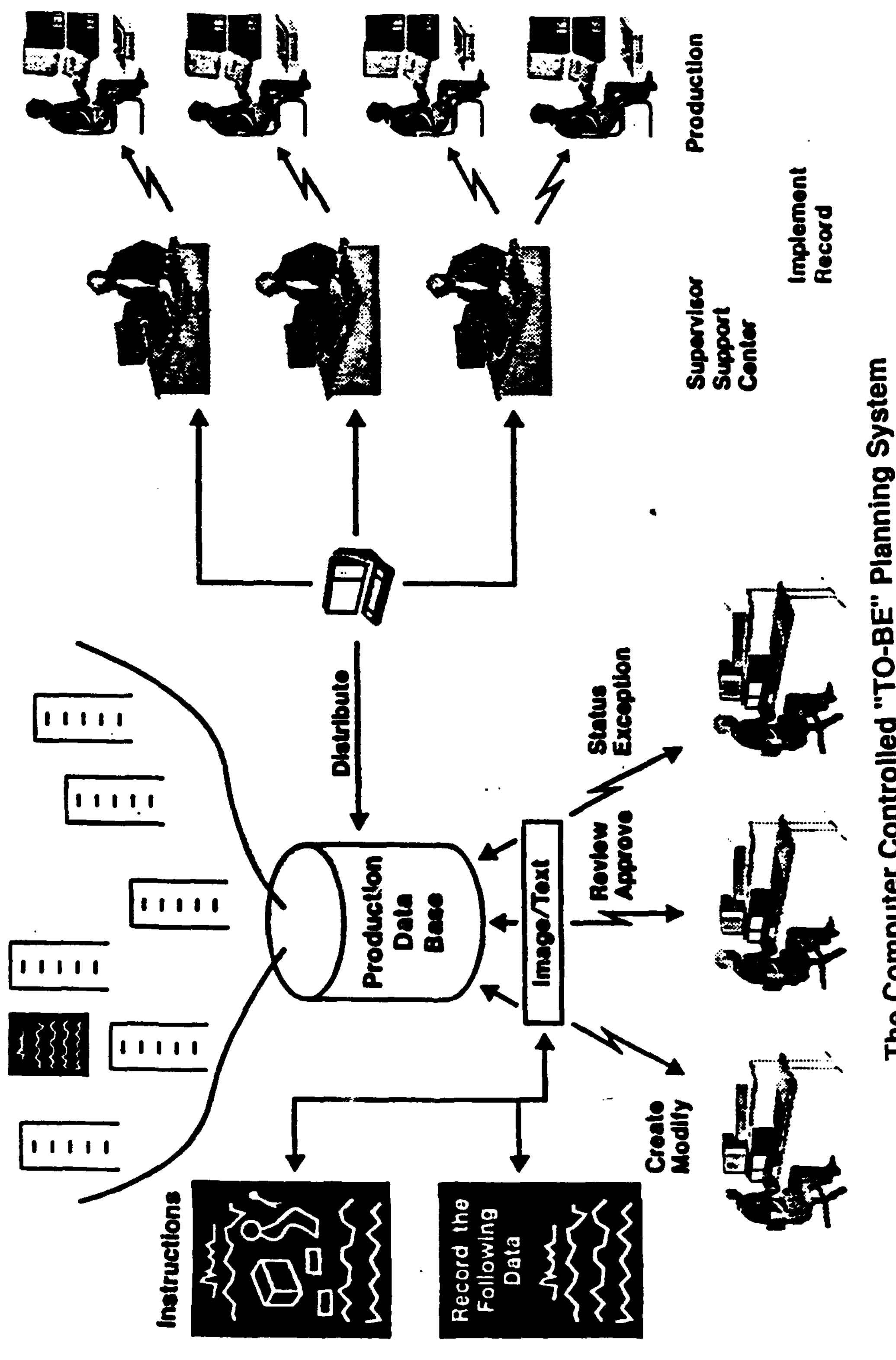


Figure 13.2. "To-Be" Computerized Planning System

To effectively schedule and allocate labor to a job, machine, team, etc., the scheduling team needs control of and access to up-to-date information about employees. The employee definition function consists of defining attributes about an employee and the relationship to one or more work centers. Key attributes include:

- Employee number or badge number
- Employee name
- Work skills
- Certification data operations and levels
- Base work center - normal assignment
- Current work center - loan or temporary
- Function
- Work Shift
- Cost center
- Labor type
- Machine assignment
- Supervisor

WCM - Operational Scenario

Data flows through the system invisibly to each user. Any user will be able to view the system and all of its machines and data bases as one "whole". Each user will have a default WCM to which they will automatically be connected depending upon the physical location of the workstation. For example, an engineer's workstation will automatically be connected to the WCM which contains the Process Definition and Discrepant Material data bases. Each operator will be connected to the WCM which contains the Shop Floor data base which is responsible for the physical location where the terminal is located. Each supervisor's terminal will be connected to the WCM which contains the Shop Floor Control data base which is responsible for the physical location for which the supervisor is responsible.

WCM - Hardware/System Configuration

The modules within the application process that will be required to accomplish the identified functionality are:

- Process Definition (PD) - As previously identified, this module will be used in maintaining and distributing build process instructions for use in the actual work stations.

- Document Management (DM) - This module will be used under the direction and control of Process Definition to manage the compound document used at the actual work stations to accomplish builds. A DM module will be available at each workstation to maintain control over the documents stored there.

- Work Station (WS) - This module will control all processes available to either a workstation operator or engineer.

- Shop Floor Control (SFC) - This module will be the control module for all operators using the system. By use of menu's and pre-defined capabilities, the SFC module will contain all the data necessary to track each operation for a build through to its completion.

- Build History (BH) - This module will be located where all Build History is stored. All reports requiring the use of Build History will be generated from this module.

- Action Register (AR) - This discrepant materials module will be located where all Action Register data (instructions as well as history) is stored. All AR functions will be accomplished through the use of this module. There will be a connection within the build history data for any relating AR data to that build process.

- Print (PR) - This module will be responsible for actual reporting of information requested by the user. The actual data will be retained within its appropriate data base, but the reports will be generated through the use of this module.

- Application Administration (AA) - This module will be located where all supporting functions are performed. Functions may include:

  - Establishing data base records to identify required information such as program category, group, etc.

  - Introducing parts and serial numbers for those parts.

- System Administration (SA) - This module will be responsible for system support functions required to enable the previously identified modules to function properly. System support function may include file dual writes, message processing, password modification, console message handling, etc.

- Scheduling/MRP (MRP) - This module will be responsible for obtaining and directing all interaction to and from the enterprise level MRP system and the Shop Floor Control modules. Any coordination of schedules between locations controlled by different Shop Floor Control nodes will be accomplished in the Scheduling/MRP function.

WCM - Workstations

Work stations are used by, but not limited to, engineers, operators, inspectors, and supervisors. Small clusters of workstations are connected and controlled by a workstation controller which is a computer-based system executing software that supports engineering and factory applications.

A high resolution color graphics board resides in the workstation controller to provide real time image acquisition and display.

The workstation controller interfaces to workstations, interfaces to the Local Area Networks (LAN), and executes applications that support the interaction with the operator. These application interactions include, but are not limited to, collection of data, display of graphics, creation of drawings, and the creation and display of textual data.

- Engineering Workstation

  An engineering workstation consists of a Honeywell PC AP connected to a workstation controller. Under control of the workstation, graphics, text, and other forms of data are passed directly to the PC graphics board while other commands from the workstation will cause files to be transferred to the PC or programs to be executed locally in the PC.

- Operator/Inspector Workstation

  The operator & inspector workstation consists of a color monitor and keyboard connected to a workstation controller. All functions for an operator workstation execute in either the workstation controller or some other computer in the LAN (i.e., SFC, Process Definition, AR, etc.).

- Supervisor Workstation

  (Same as Engineering Workstation, in some instances scaled down to only a receiving Terminal)

System Resiliency

There are two aspects of system resilience. They are the abilities to recover from hardware and software faults in a reasonable time; however, the definition of "reasonable time" is different for each functional node. In this design, each operator workstation has most of the layout, forms, and graphics needed for it to be operational with some degree of independence from its master node. If the Shop Floor Control platform goes down, the operator workstation can continue until the data for the current operation has been input. The data will simply be buffered in the local workstation. When the Shop Floor Control platform becomes available, the operator workstation can resume sending data. From a production standpoint, the Shop Floor Control platform can be down for short periods of time with little or no impact on production.

Shadowed Data Bases

The file systems of all platforms will be shadowed to another hardware platform. The purpose of the shadow platform is to maintain an on-line copy of all file structures. The shadow copy of a Shop Floor Control platform can be used to recreate the software identity of a failed hardware platform without the use of tape. It is important to understand that the shadow platform is not intended to be an alternate platform to be used when the main system is down. It is wise to take a tape save of the file structure on some regular schedule and send it to off-site storage to protect against fire or worse. However, any use of these tapes to recover from a platform that has faulted will not meet the requirement of "reasonable time" implied in System Resilience. If the save tapes were created while the system was in production, they would not represent a clean point in time. They would contain unique problems not planned for in the system design. If the save tapes were created when no activity was occurring to the file system, they could be used to restore the file system to a known state.

See Figure 13.3 for an illustration of the Honeywell Paperless Factory architecture.

Cost Justification

The implementation of a project of this magnitude, that will totally revise the present method of operations, is not an inexpensive or quickly achieved task, but it is a mandatory one for Aerospace and Defense companies. The primary reasons to make this commitment are:

- Department of Defense data submittal requirements in the 1990's will be electronic media versus present paper and microfilm.
- Required to stay cost competitive.
- Required to fully comply with DOD specifications for document control.

It is easily recognizable that the "Paperless Factory" concept would provide cost reductions; but, due to the intangible factors, it is difficult to precisely define a formula to calculate how much could be reduced and where it would occur. It is cost effective to have the right information at the right place at the right time, but how much does it cost if this does not occur? An easy calculation would be the savings in the cost of floor space by electronic data storage and distribution, compared with file cabinets and Xerox; but, how is the value of on-line access to current data calculated?

The best approach is to start with the Cost of Quality concept and determine the WCM interaction with this concept. The Cost of Quality is defined as the percentage of gross sales dollars that is spent to meet customer requirements (technical, quality, etc.), because things are not done right the first time. This is defined as the Cost of Non-Conformance which results in the following inefficiencies:

- Rework
- Redesign
- Repair
- Warranty work
- Revisions to Documentation
- Change orders (to fix errors)
- Past due receivables
- Faulty spare parts
- Billing errors
- Payroll errors
- Retyping
- Unplanned inventories

- Troubleshooting
- Failure Analysis
- Failure Reporting
- Incorrect configurations
- Cost of litigation
- Incorrect system ships

The WCM will have a significant positive impact on many of the nineteen categories listed above.

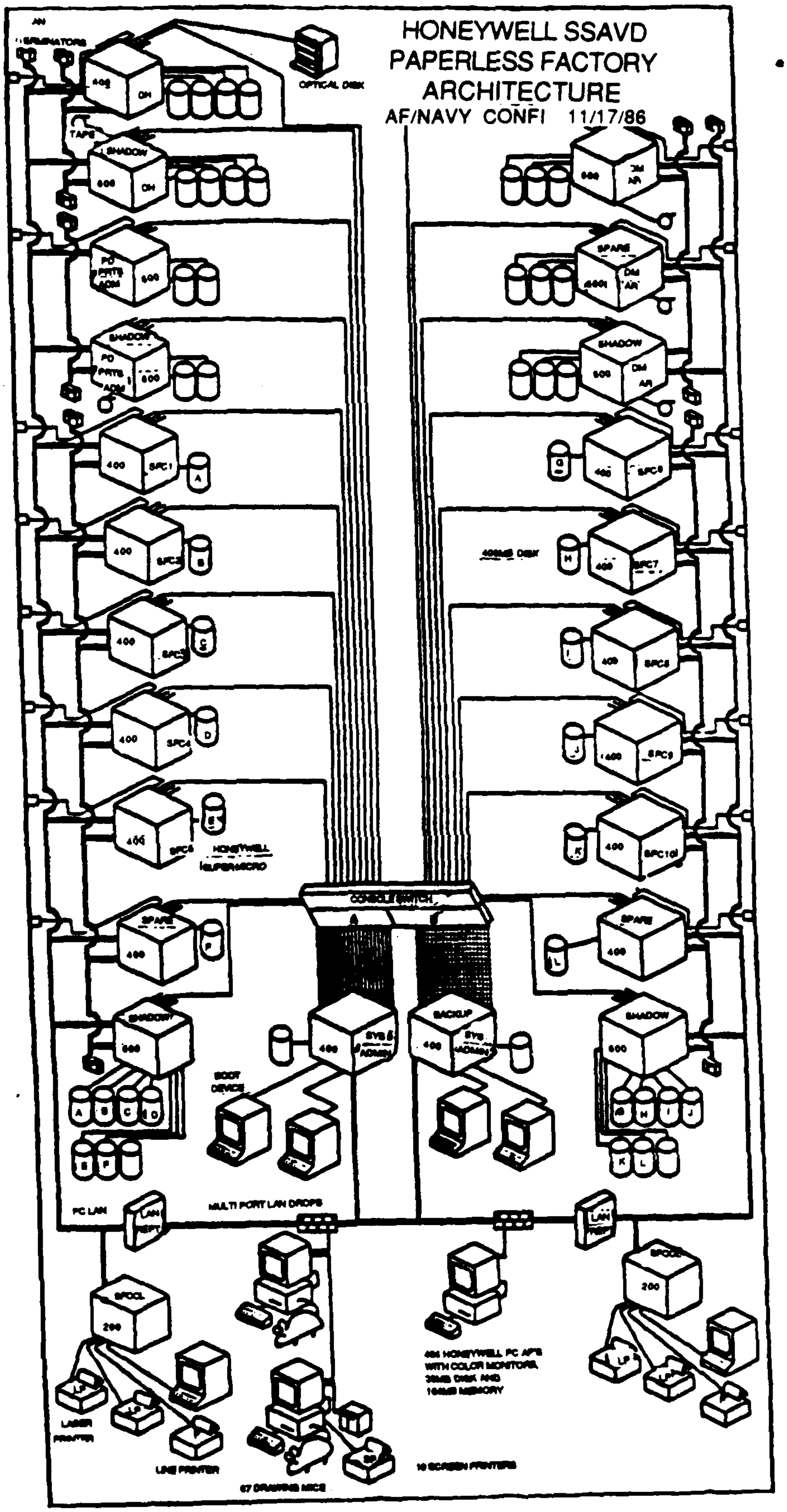


Figure 13.3. Long Range Plan for the Honeywell Paperless Factory

SECTION 14

COST BENEFIT ANALYSIS/PROCEDURE

The analysis of Project 51/52 was initially based on five independent product groups within Inertial Instruments Operations (IIO). Those groups were 1) GG1111 main gyro line, 2) GG4400 main gyro line, 3) GNAT main gyro line, 4) Packages, and 5) Miscellaneous Device and gyro line. The Miscellaneous group was terminated in preliminary design due to the initial analysis showing no savings.

The five cost drivers listed below were used to calculate savings for each of the four remaining product groups. These cost drivers are 1) Actual Standard Hours, 2) Rework Hours, 3) Scrap Dollars (labor and material), 4) Floor Space, and 5) Tooling Support Dollars. These cost drivers were identified using the methodology shown in the process diagram of Figure 14.1.

The methodology used to evaluate each of the five cost drivers listed above is identified as follows:

1. ACTUAL STANDARD HOURS

The "As-Is" standard hours were taken from an internal Honeywell "Standard Hour Listing". This is a listing by part number of the frozen standards that are used to establish part and device costs on an annual basis.

The "To-Be" standard hours were either established by Industrial Engineering or project consultants and Honeywell production engineers (PE). The time standards originally estimated by the project consultants or PE's were reviewed and edited by Industrial Engineering staff.

Industrial Engineering developed these standards using three main sources. These were: 1) "MOST", Maynard Operation Sequence Technique, a predetermined motion time system based on MTM1 (Method Time Measurement), 2) revision of existing time standards, using elemental times from current time studies or standard data to establish new standards, 3) vendor recommendations for feeds, speeds, and process times for equipment not yet in-house.

An efficiency or performance factor was added to both the "As-Is" and "To-Be" standard labor hour before savings were calculated. This adjustment converted the standard labor hours required to produce a product to the actual labor hours to produce the product. The "As-Is" performance for each product group was taken from Industrial Engineering's 1986 performance history. After evaluation by Industrial Engineering, the projected "To-Be" performance will remain the same as the "As-Is".

Due to individual parts or assemblies presently having both assembly (Project 51) and Fabrication Facility (Project 44) labor performed, the department generating labor in the

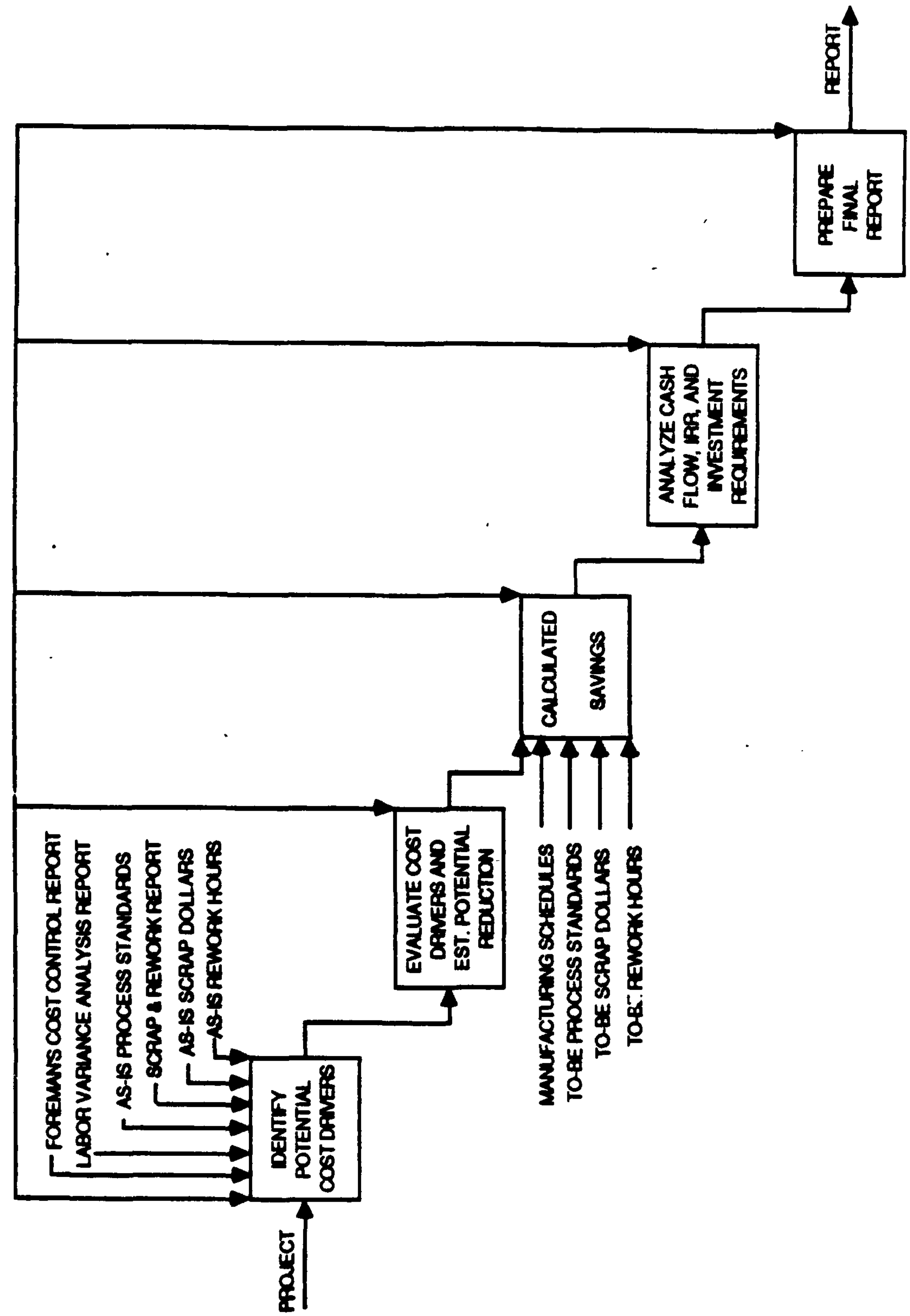


Figure 14.1. Cost Benefit Analysis Methodology

"To-Be" process will realize the savings. All "To-Be" processes will have no combination or cross-departmental parts or assemblies.

2. REWORK HOURS

Honeywell's "Foreman's Cost Control Report" was analyzed to determine the average rework per assembly for a period of 15 months, January 1986 through March 1987. Industrial Engineering and Production Engineering Supervision estimated an approximate percentage reduction in rework hours that should be attained due to the implementation of high precision assembly tooling and equipment as well as better work flow of the product. The percent reduction ranged from 25 to 50% depending on product group over a ten year period.

3. SCRAP DOLLARS

Honeywell's "Labor Variance Analysis" and "Scrap and Rework" reports were used to determine the average scrap dollars per assembly. Based on the same criteria as rework savings, Industrial Engineering and Production Engineering supervision estimated a percentage reduction by product group. The reduction ranged from 25 to 40% percent over a ten year period.

4. FLOOR SPACE

Industrial Engineering compared the "As-Is" and "To-Be" floor space and determined that the "To-Be" floor allocation required additional square footage in each of the product areas. The areas included in the comparison were production, inspection, shipping, support offices, conference room, break room, clean room, and locker room.

5. CONTINUED SUPPORT TOOLING DOLLARS

The tooling support dollars were determined by the comparison of the 1986 actual dollars expended per product family and the volume of product actually shipped. An estimated 25% increase in tooling support cost per unit was used to generate the "To-Be" costs. This percentage was derived through the evaluation of proposed tooling, either simplified or complex, and/or Honeywell personal experience.

CAPITAL AND EXPENSE

The capital, recurring and non-recurring expenses for Project 51/52 are shown in Figure 14.2.

		Gross Cost	Capitalization Date
CAPITAL COSTS			
MACHINERY COST			
		$2,492,113	1988
		$2,492,113	1989
		$0	1990

	SUB-TOTAL	$4,984,227	
FURNITURE COST			
		$419,449	1988
		$419,449	1989
		$0	1990

	SUB-TOTAL	$838,898	
AUTOMATIC TEST EQUIPMENT (ATE) COST			
		$2,339,770	1988
		$2,339,770	1989
		$0	1990

	SUB-TOTAL	$4,679,540	
COMPUTER COST			
		$1,525,310	1988
		$1,525,310	1989
		$0	1990

	SUB-TOTAL	$3,050,621	
TOOLING COST		$228,325	1988
		$362,646	1989
		$286,258	1990

	SUB-TOTAL	$877,230	
		$7,002,969	1988
		$7,129,290	1989
		$286,258	1990
TOTAL CAPITAL COST		$14,430,516	

• SALES TAX IS APPLIED TO MATERIAL PORTION OF CAPITAL ONLY.

		Gross Cost	Year Expended
EXPENSE COST			
NON-RECURRING EXPENSES			
		$534,230	1988
		$832,405	1989
		$704,024	1990

	AREA PREP (HI)	$2,070,660	
		$962,659	1988
		$1,499,957	1989
		$1,268,621	1990

	IMPLEMENTATION (HI)	$3,731,237	
		$87,451	1988
		$136,261	1989
		$115,245	1990

	SOFTWARE	$338,957	
		$1,584,340	1988
		$2,468,623	1989
		$2,087,890	1990.
TOTAL NON-RECURRING COST		$6,140,854	
TOTAL CAPITAL AND NON-RECURRING		$20,571,371	
RECURRING EXPENSES			
	ANNUAL MAINTENANCE	$120,510	
TOTAL RECURRING COST		$120,510	

Figure 14.2. Project 51/52 Expenditure Schedule

PROJECT SAVINGS AND CASH FLOWS

The savings to be realized by this project exceeds Honeywell's Military Avionics Division hurdle rate. The Projects' cash flows are shown in Figure 14.3 with the assumption that capital is available per the implementation plan.

TECH MOD PHASE 2

PROJECT 51/52

PROJECT CASH FLOW SUMMARY
($000)

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	TOTAL
Capital Facilities	7,003.0	7,129.3	298.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14,430.5
Non-Recurring Expense	1,584.3	2,468.6	2,087.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6,140.9
Related Expenses	0.0	0.0	87.9	120.5	120.5	120.5	120.5	120.5	120.5	120.5	120.5	120.5	32.6	1,205.1
Savings	0.0	1,111.2	5,248.1	7,366.2	7,770.9	8,203.6	8,692.9	9,194.7	9,621.9	10,093.0	10,591.1	9,839.8	1,383.8	88,917.1
Depreciation	787.1	2,205.1	2,675.6	2,214.7	1,800.0	1,318.8	909.4	773.5	687.4	503.1	321.9	153.9	69.9	14,430.5

Figure 14.3. Project 51/52 Cash Flows

SECTION 15

IMPLEMENTATION PLAN

The IIO Implementation Plan evolved from a series of steps which began with the development of the ten year Strategic Plan. The Strategic Plan revealed a need for expansion in floor space for the Ring Laser Gyro (RLG) and Iron Gyro (PCI) factories, with RLG expansion being the initial driver for the required floor space. Further, it was determined that the first floor of the Stinson/Ridgway building would not accommodate the required floor space expansion.

To accommodate expansion of the first floor, which is best suited for factory floor space, the Systems and Research Center (S&RC) was moved from the second and third floors of the Stinson/Ridgway facility to a new facility. The S&RC move then freed floor space for the move of indirect support services (e.g., Information Systems Management, Document Control, and the cafeteria) from the first floor to the second and third floors of the facility.

The results of those moves will provided ample floor space for an orderly expansion and reorganization of the "To-Be" factory on the first floor of the Stinson/Ridgway building. Figure 15.1 depicts the planned space distribution of the "To-Be" factory which includes all of IIO's production area, including the RLG-Laser production area and the Development and Evaluation laboratories (D & E labs).

The magnitude of this move encompasses more effort than could be funded or physically completed in a one year time period. As a result, a phased implementation plan was developed to accommodate production requirements given the funding and resources available. The phased plan is shown in Figure 15.2.

DESCRIPTION OF IMPLEMENTATION PLAN ACTIVITIES

The following is a general description of the activities as listed on the attached PCI Implementation Master Plan, Figure 15.3, and the individual implementations plans for the four product areas (see Figures 15.4 through 15.6). These figures depict the GG1111, the GG4400/GNAT, and the Packages product areas, respectively. As the PCI Implementation Master Plan highlights, the implementation of each of the four product groups is planned in two steps. The first implementation step covers the preparation of the facility for the first move of the "As-Is" equipment, whereas Step 2 is designed as the final implementation phases for converting the "As-Is" factory to the new "To-Be" design. Step 2 concludes the entire Phase III Tech Mod effort.

Since implementation schedules of the four product groups did not coincide and were considered independent from each other, the team developed three sets of implementation plans. The three plans cover the GG1111, the GG4400/GNAT, and the Packages areas respectively. Figures 15.4 through 15.9 cover these implementation plans. Figures 15.4 through 15.6 depict the master implementation plans for each of the three areas (i.e., GG4400 and GNAT are considered one area). Figures 15.7 through 15.9 display the detail implementation plans for Step 2 implementation only. The Master Implementation Plan for each area spans the entire time frame: Step 1 through Step 2 implementation and Phase III validation. As the Detail Implementation Plan reveals, the team has chosen to organize these plans according to Buffer, Subassembly, and Final Assembly areas.

The Master Implementation Plan for each area is divided into the following time frames and activities:

- Facility preparation
- Step 1 move ("As-Is" factory/implementation)
- Piloting and finalizing the "To-Be" processes
- Piloting and finalizing the "To-Be" controls and systems
- Design/finalizing of equipment and tooling
- Finalizing/procuring of hardware and software
- Finalizing/executing a training program
- Step 2 ("To-Be" factory) implementation
- Fine tuning of the "To-Be" factory/validation (Phase III)

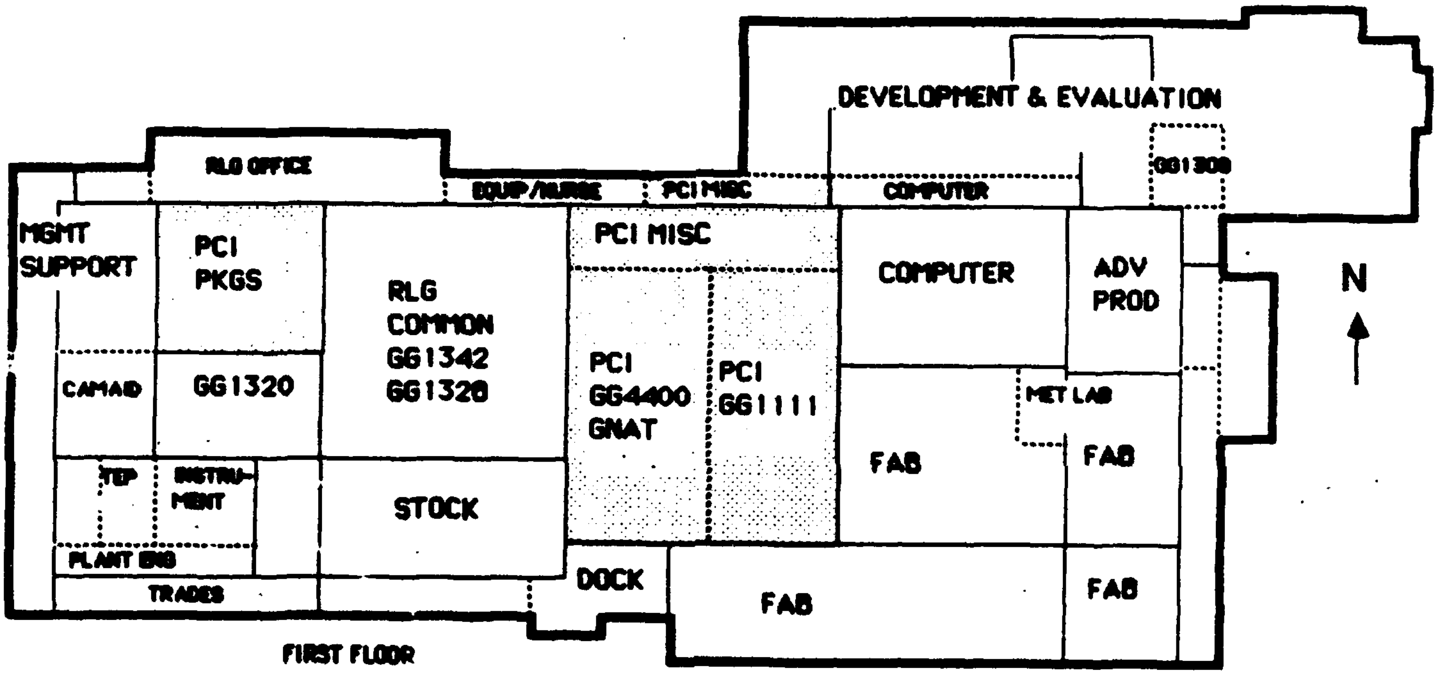
Facility Preparation

Finalizing shop floor layouts is considered a plant engineering activity with heavy input from the production engineering staff and line management. It primarily consists of preparing actual architectural plans for the modification of the existing building relative to the location of each individual product area. It further includes the scheduling/planning for the removal of existing walls, location of offices, rest rooms and breakrooms, and all the utilities as specified for the "To-Be" factory. Since the GG1111 product area already has reached the window for Step 1 implementation (see the PCI Implementation Master Plan), those activities already have begun.

The modification and/or demolition of the existing facility also already is underway with respect to the planned move for Step 1 of the GG1111 product area, which is the first of the four product areas to be moved.

IIO PROPOSED "TO BE PLAN"

STINSON/RIDGWAY FACILITY



HONEYWELL INC.
Military Avionics Division
Stinson/Ridgway

NOTE: Shaded Areas Indicate Location of Proposed 4 Assembly Lines

Figure 15.1. IIO Distribution Plan for the "To-Be" Factory

MAJOR IIO - FACILITIES PROJECTS

STINSON/RIDGWAY FACILITY

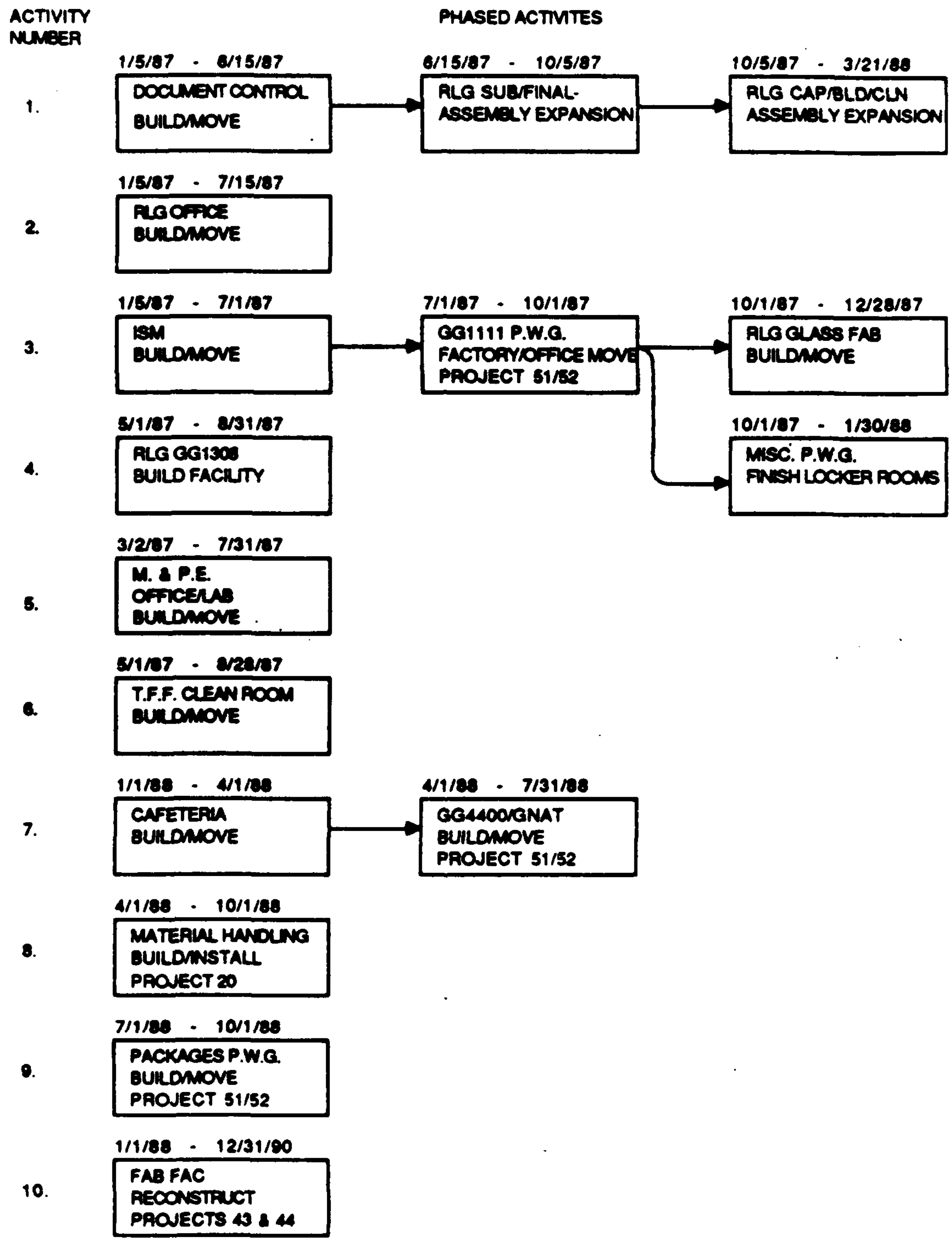


Figure 15.2. Planned IIO Facility Projects (1987-1990)

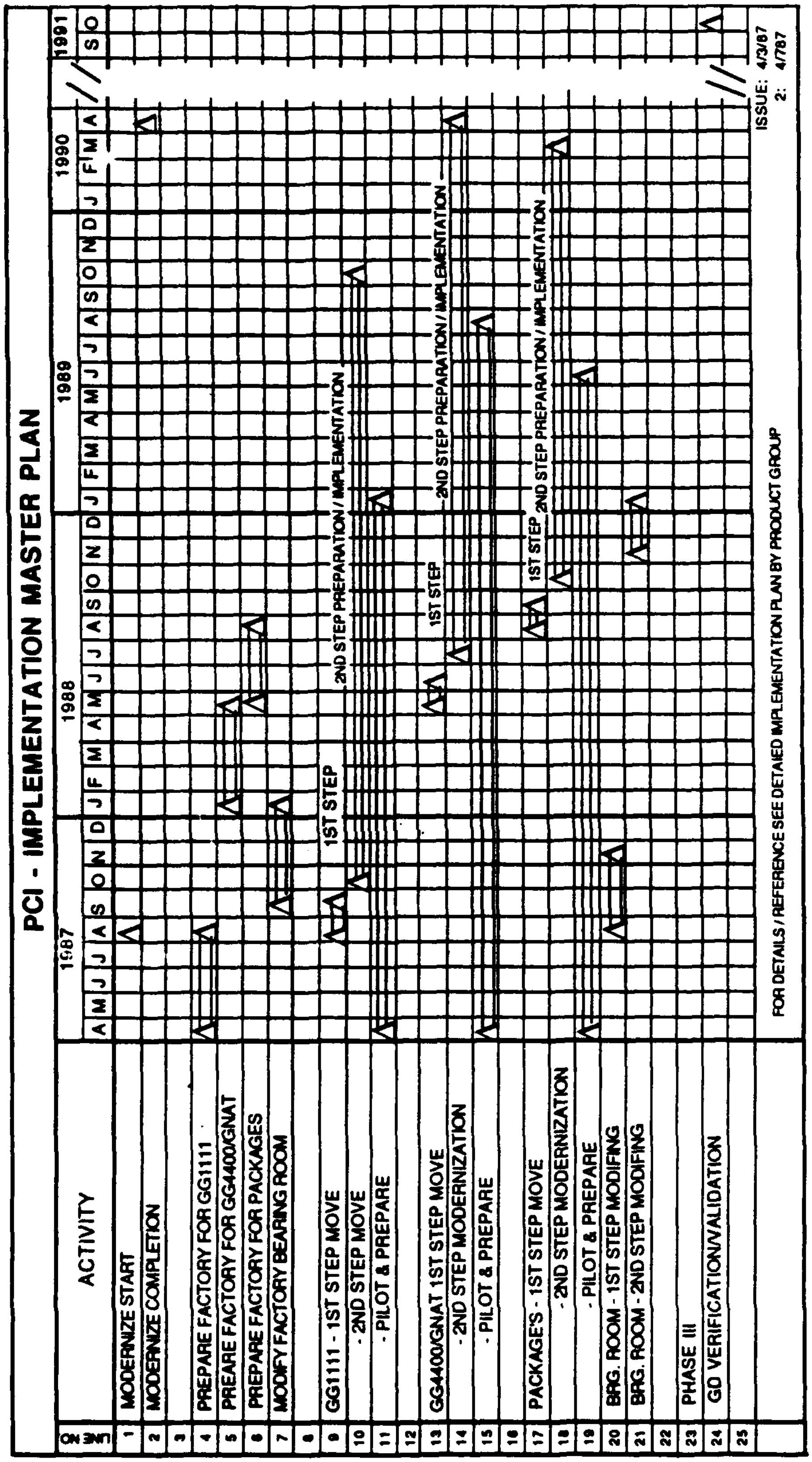


Figure 15.3. PCI Implementation Master Plan (all four product areas)

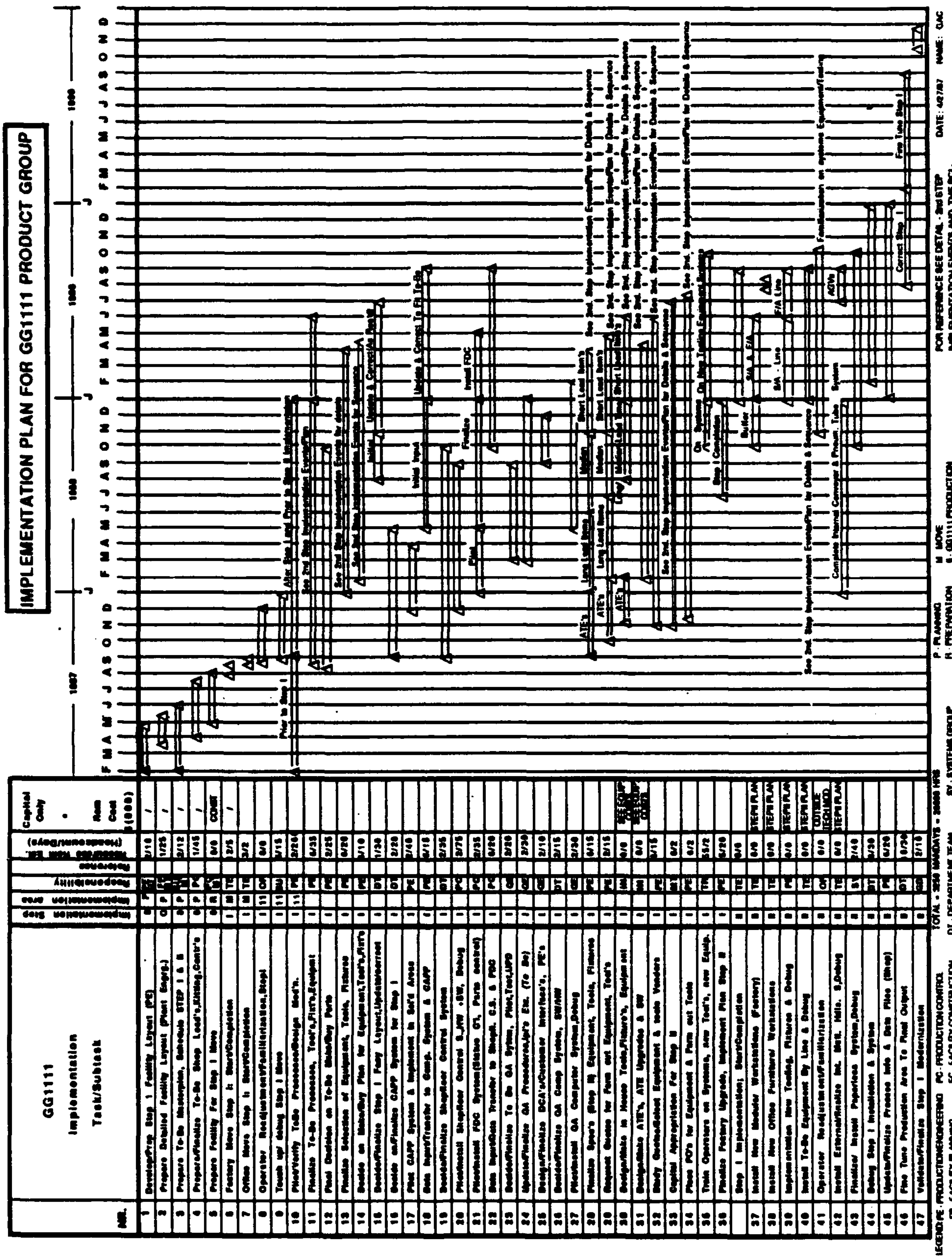


Figure 15.4. Master Implementation Plan for the GG1111 Device (Reference PCI Master Plan)

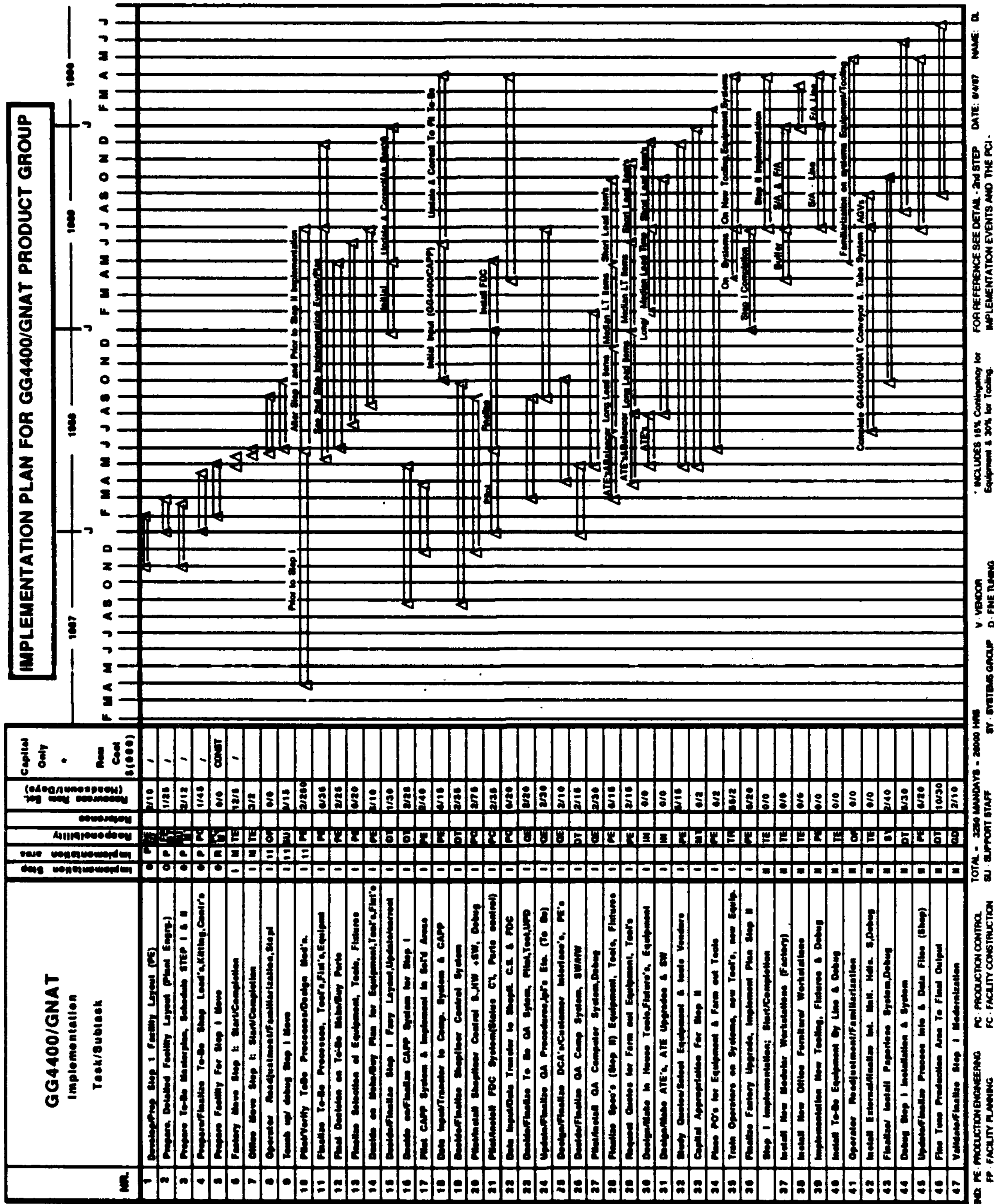


Figure 15.5. Master Implementation Plan for the GG4400/GNAT Device (Ref. PCI Master Plan)

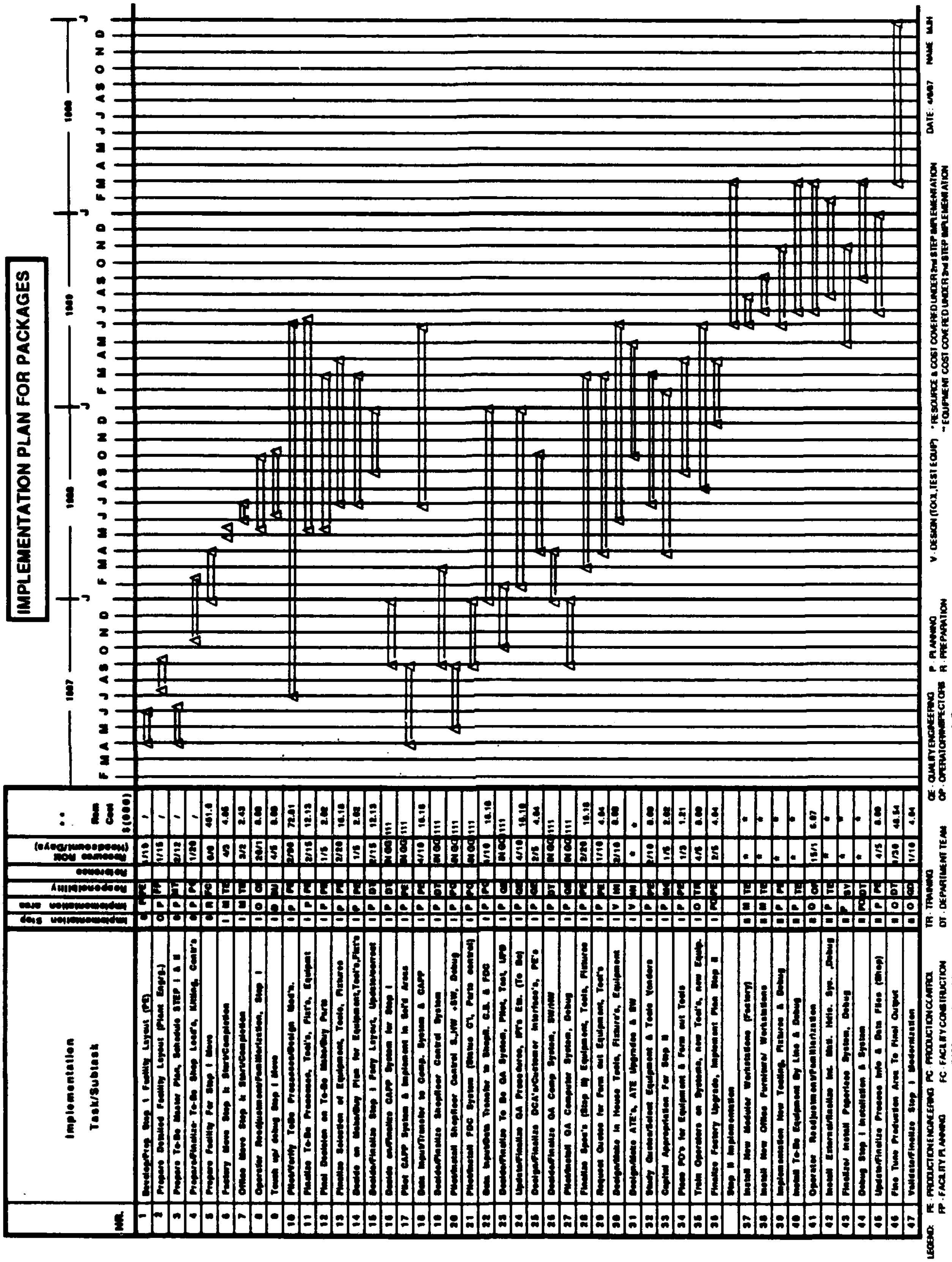


Figure 15.6. Master Implementation Plan for Packages (Ref. PCI Master Plan)

Reference:
PCI Implementation Master Plan
Buffer Area *

2nd STEP GG1111 IMPLEMENTATION EVENTS

PRODUCT GROUP / AREA : GG1111 PRODUCT GROUP/AREA

(2nd STEP IMPLEMENTATION TIME FRAME - 9 MONTHS, JAN 89 TO SEPT 89)

DURATION IN MONTHS: 1–18 (Jan 1989, Feb 1989, Mar 1989, Apr 1989, May 1989, Jun 1989, Jul 1989, Aug 1989, Sep 1989, Oct 1989, Nov 1989, Dec 1989)

NR.	Implementation Area Activity	MAKE / BUY	Responsibility	Resource ROM (Headcount/Days)	* Rom Cost $(000)	Remarks
1	PREPARATION OF FACILITY	M	FC		CONSTR.	PRIOR TO STEP I IMPLEMENTATION (PRIOR TO AUG. 87) IN CONJUNCTION WITH SUB ASSEMBLY AREA
2	INSTALLATION CONVEYOR SYSTEM	B M	V PC	3 / 12	63.66	AFTER STEP I IMPLEMENTATION BUT BEFORE STEP II IMPLEMENTATION (FROM AUG 87 TO JAN 89) IN CONJUNCTION WITH SA-FA AREAS
3	INSTALLATION PNEUMATIC TUBES	B	V	3 / 5	17.37	AFTER STEP I IMPLEMENTATION BUT BEFORE STEP II IMPLEMENTATION IN CONJUNCTION WITH SA-FA AREAS
4	MOVE OF BOTH LASERWELDERS - C02 YAG	M	PE PC	3 / 5	CONSTR.	DURING STEP I IMPLEMENTATION (AUG. 87)
5	MOVE FINAL INSPECTION TO BUFFER (Q.A.)	M	QE PE	2 / 1	CONSTR.	DURING STEP I IMPLEMENTATION (AUG. 87)
6	INSTALLATION C02 YAG GAS SUPPLY	M	FC	1 / 3	CONSTR.	PRIOR TO STEP I IMPLEMENTATION (PRIOR TO AUG. 87)
7	SET-UP BUFFER - CLEANROOM	B	PE PC	2 / 10	CONSTR.	PRIOR TO STEP I IMPLEMENTATION (PRIOR TO AUG. 87)
8	SET-UP WORK BENCHES/FURNITURE	B M	FC	3 / 2	46.7	ORIGINAL ONES DURING STEP I IMPLEMENTATION, TO BE STATIONS PRIOR TO STEP II IMPLEMENTATION (AUG. 87 TO JAN. 89)
9	INSTALLATION STORAGE SYSTEM	B	PE PC	2 / 15	155.48	ORIGINAL STORAGE DURING STEP I IMPLEMENTATION, VARIES PRIOR TO STEP II IMPLEMENTATION (AUG. 87 TO JAN 89)
10	INSTALLATION LASER MARKER	B	PE PC	2 / 4	65.76	
11	INSTALLATION ADDITION LEAK TESTER	B	PE PC	1 / 1	AVAL.	
12	INSTALLATION ROBOT CLEANING CELLL	B M	PE PC	2 / 10	74.75	
13	SET-UP COMP CONTROL ROOM	B	PC PC	3 / 20	RICHARD	
14	INSTALLATION SMALL EQUIPMENT	B	PE PC	1 / 2	1.61	
15	INSTALL/ACTIVE DISPACHING SYSTEM	B M	PE PC	2 / 10	ROM 40.5	
16	INSTALL CONTAINER WASHER & DRYER	B M	PE PC	1 / 1	.53	
17	USE OF PROTECTIVE CONTAINER	B	PE PC	1 / 1	ROM 11.6	PRIOR TO STEP II IMPLEMENTATION (BEFORE JAN. 87)
18	INSTALL EXTERNAL 'AGVS'	B	V PE	2 / 5	$173.5	
19	SET-UP MATERIAL PREP AREA	B M	PE PC	2 / 2	11.5	
20	SET-UP COMPUTE - HW/SW	B M	V PC	3 / 40	18.06	
21	INSTALL BAR CODE LABELER	B	PE	1 / 2	30.8	AFTER STEP I IMPLEMENTATION BUT BEFORE STEP II (IMPLEMENTATION (FROM AUG. 87 TO JAN. 89)
22	INSTALL PARTS -SEALER	B	PE	1 / 1	17.25	AFTER STEP I IMPLEMENTATION BUT BEFORE STEPP II IMPLEMENTATION (FROM AUG. 87 TO JAN 89)
23	COMPLETE BUFFER INSTALLATION	M	PE PC	3 / 5	ROM 11.6	
24						
25						
26						
27						
28						
29						
30						
31						
32						
33						
34						
35						
36						
37						
38						
39						
40						
41						
42						
43						
44						
45						
46						
	SUBTOTAL/TOTAL			402		

LEGEND. M Make, B Buy, V Vendor; FC Facility Construction, PE Production Engineer, PC ProductionControl; QE Quality Engineering

* Includes Contingency 15%

(Second Step Implementation Events Only)

(* Subassembly / Final Assembly Listing See Pages 2 - 8)

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Figure 15.7. Implementation Events: Details for Step 2 GG1111 Implementation (Buffer Area)

Reference:
PCI Implementation Master Plan
SUBASSEMBLY AREA

2nd STEP GG1111 IMPLEMENTATION EVENTS

PRODUCT GROUP / AREA : GG1111 PRODUCT GROUP/AREA
(2nd STEP IMPLEMENTATION TIME FRAME - 9 MONTHS, JAN 89 TO SEPT 89)

NR.	Implementation Area Activity	MAKE / BUY	Responsibility	Resource ROM (Headcount/Days)	* Rom Cost $(000)	Duration in Month: 1 Jan 1989 – 18 (Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec 1989)
24	PREPARATION OF FACILITY	M	FC		CONSTR.	PRIOR TO STEP I IMPLEMENTATION (PRIOR TO AUG. 87) IN CONJUNCTION WITH SUB ASSEMBLY AREA
25	INSTALLATION CONVEYOR SYSTEM	B/M	V/FC	3 / 15	203.21	AFTER STEP I IMPLEMENTATION BUT BEFORE STEP II IMPLEMENTATION (FROM AUG TO JAN 81) IN CONJUNCTION WITH SA+FA AREAS
26	INSTALLATION PNEUMATIC TUBES	B	V	3 / 3	9.67	AFTER STEP I IMPLEMENTATION BUT BEFORE STEP II IMPLEMENTATION IN CONJUNCTION WITH S/A+F/A AREAS
27	SET-UP S/A CLEAN ROOM(S)	B/M	PE/FC		CONSTR.	PRIOR STEP I IMPLEMENTATION (PRIOR TO AUG. 87)
28	SET-UP S/A-SHOP OFFICES	M	FC		CONSTR.	PRIOR STEP I IMPLEMENTATION (PRIOR TO AUG. 87)
29	SET-UP S/A - SUPPORT OFFICES	M	FC		CONSTR.	PRIOR TO STEP I IMPLEMENTATION (PRIOR TO AUG. 87)
30	CONSTRUCTION/SET-UP BREAKROOM	M	FC		CONSTR.	PRIOR TO STEP I IMPLEMENTATION (PRIOR TO AUG. 87)
31	CONSTRUCTION/SET-UP RESTROOMS	M	FC		CONSTR.	PRIOR TO STEP I IMPLEMENTATION (PRIOR TO AUG. 87)
32	MOVE AS-IS CABLE CELL	M	PE/FC	2 / 2	CONSTR.	DURING STEP I IMPLEMENTATION (AUG/SEP 87)
33	SET-UP TO-BE CABLE CELL	B/M	PE/FC	2 / 7	6.9	
34	MOVE TO-BE COIL CUP TORO. CELL	M	PE/FC	2 / 3	CONSTR.	DURING STEP I IMPLEMENTATION (AUG./SEP. 87)
35	SET-UP TO-BE COIL CUP TORO. CELL	B/M	PE/FC	2 / 10	22.65	
36	MOVE AS-IS HEADER S/A-LINE	M	FC	3 / 5	CONSTR.	DURING STEP I IMPLEMENTATION (AUG./SEP. 87)
37	SET-UP TO-BE HEADER S/A-LINE	B/M	PE/FC	5 / 20	121.0	
38	MOVE AS IS GIMBAL S/A-LINE	M	FC	3 / 5	CONSTR.	DURING STEP I IMPLEMENTATION (AUG./SEP. 87)
39	SET-UP TO BE GIMBAL S/A-LINE	B/M	PE/FC	5 / 12	47.73	
40	INTEGRATE LASER BALANCER	B/M	PE/QE	1 / 15	ROM 4.0	
41	IMPLEMENT TO-BE MOTOR ROBOT CELL	B/M	PE/FC	3 / 20	132.6	
42	MOVE AS-IS MOTOR LINE	M	FC	2 / 5	CONSTR.	DURING STEP I IMPLEMENTATION (AUG./SEP. 87)
43	SET UP TO BE MOTOR LINE	B/M	PE/FC	2 / 15	6.9	
44	INSTALL INJECTION MOLDING EQUIPMENT	B/M	PE/V	2 / 7	32.2	
45	INSTALL (3) CNC-WINDER	B/M	PE/V	2 / 9	133.52	
46	INSTALL SPEC. MACHINES FOR HEADER & GIMBAL	B/M	PE/V	2 / 7	312.8	
47	INSTALL S/A - FLOW THRU OVENS	B/M	PE/V	2 / 15	8.68	HW/SW - CHANGEOVER COMPLETE
48	UPGRADE/SET-UP ATE MOTOR RUN-IN	B/M	PE/V	2 / 12	172.5	UPGRADE
49	INSTALL TEMP. CYCLING OVENS GIMBAL & HEADER	B/M	PE/V	2 / 10	395.6	
50	INSTALL ADVD MGMT CHARGER F. HEADER	B	PE/V	1 / 3	30.48	
51	INSTALL GIMBAL BALL & INSERT INSERTER	B/M	PE/V	1 / 4	30.25	
52	IMPLEMENT ADVD. TOOLING GIMBAL LINE	M	PE	5 / 5	115.5**	
53	IMPLEMENT ADVD TOOLING HEADER LINE	M	PE	5 / 5	47.9**	
54	IMPLEMENT ADVD. TOOLING MISC. CELLS	M	PE	5 / 7	152.9**	CABLE CELL – COIL CUP CELL – MOTOR CELL
55	INSTALL SMALL ELECTRIC TESTER GIMBAL HEADER	B/M	PE	5 / 10	81.06	
56	INSTALL REMAINING SMALL EQUIPMENT	B/M	PE	5 / 15	47.73	
57	INSTALL WORKSTATIONS/SHOP FURNITURE	B	PE/FC	3 / 4	121.33	CABLE CELL – COIL CUP CELL – HEADER LINE – GIMBAL LINE
58	COMPLETE S/A - INSTALLATION	M	PE/FC	5 / 20	ROM 28	
59	SET-UP COMPUTER - HW/SW	B/M	V/FC	2 / 60	RICHARD	
60	REPLACE S/A OFFICE FURNITURE	B	PE/FC	3 / 1	23.8	
	SUBTOTAL/TOTAL			1055		

LEGEND M MAKE, B BUY, V VENDOR; FC FACILITY CONSTRUCTION, PE PRODUCTION ENGINEER, PC PRODUCTION CONTROL; QE QUALITY ENGINEERING
* INCLUDES CONTINGENCY 15%

(SECOND STEP IMPLEMENTATION EVENTS ONLY)
(* SUBASSEMBLY / FINAL ASSEMBLY LISTING SEE PAGES 2)

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Figure 15.8. Implementation Events: Details Step 2 GG1111 Implementation (Subassembly)

REFERENCE:
PCI IMPLEMENTATION MASTER PLAN
FINAL ASSEMBLY AREA

2nd STEP GG1111 IMPLEMENTATION EVENTS

PRODUCT GROUP / AREA GG1111 PRODUCT GROUP/AREA
(2nd STEP IMPLEMENTATION TIME FRAME - 9 MONTHS, JAN 89 TO SEPT 89)

DURATION IN MONTH: 1–18 (Jan 1989, Feb 1989, Mar 1989, Apr 1989, May 1989, Jun 1989, Jul 1989, Aug 1989, Sep 1989, Oct 1989, Nov 1989, Dec 1989, 13, 14, 15, 16, 17, 18)

NR.	Implementation Area Activity	MAKE / BUY	Responsibility	Est. Rom. Resources (MD.CT)	* Rom Cost $(000)	Schedule notes
61	PREPARATION OF FACILITY	M	FC		CONSTR.	PRIOR TO STEP I IMPLEMENTATION (PRIOR TO AUG. 87) IN CONJUNCTION WITH BUFFER & SUBASSEMBLY AREA
62	INSTALLATION CONVEYOR SYSTEM	B/M	V/PE	3/12	58.9	AFTER STEP I IMPLEMENTATION BUT BEFORE STEP II IMPLEMENTATION (FROM AUG 87 TO JAN 89) IN CONJUNCTION WITH BUFFER AREA
63	INSTALLATION PNEUMATIC TUBES	B	V	3/6	13.8	AFTER STEP I IMPLEMENTATION BUT BEFORE STEP II IMPLEMENTATION (FROM AUG. 87 TO JAN. 89) IN CONJUNCTION WITH BUFFER AREA
64	SET-UP OF F/A CLEAN ROOM	B/M	PE/FC		CONSTR.	PRIOR TO STEP I IMPLEMENTATION (PRIOR TO AUG. 87)
65	SET-UP OF F/A SHOP OFFICES	M	FC		CONSTR.	PRIOR TO STEP I IMPLEMENTATION (PRIOR TO AUG. 87)
66	SET-UP OF F/A SUPPORT OFFICES	M	FC		CONSTR.	PRIOR TO STEP I IMPLEMENTATION (PRIOR TO AUG. 87)
67	SET-UP OF CENTRAL COMP ROOM	B/M	V/PC		RICHARD	(INITIAL SET-UP OF PILOTING AFTER STEP I IMPLEMENTATION)
68	SET-UP COMPUTER - HW/SW	B/M	V/PC		RICHARD	
69	SET-UP OF ADVANCED FILL EQUIPMENT	B/M	V/PE	2/16	98.04	
70	INSTALL/SET-UP ADVANCED EQUIP F/A - CLEAN ROOM	B/M	PE/FC	2/4	17.26	
71	SET-UP RG/SPARES - AREA	M	PE/FC	2/2	116	AFTER STEP I IMPLEMENTATION - INITIAL SET-UP (AFTER AUG. 87) - FINALIZE DURING 2ND STEP IMPLEMENTATION
72	SET-UP F/A - TEARDOWN AREA	M	PE/FC	1/2	10.36	CONSTRUCTION PRIOR TO STEP I - SET-UP PRIOR TO STEP 2 IMPLEMENTATION
73	INSTALLING (2) ADDIT'L BALANCE OP. 245,250,260	B/M	PE/FC	2/7	586.5	1ST BALANCER 2ND BALANCER PUT INTO PROD.
74	INSTALLING UPGRADED #2 ATE-BALANCER	B/M	V/PE	2/16	391.0	HW/SW UPGRADE; CHANGE OVER *COMPLETE; #2 ATE; HW/SW UPGRADE; CHANGE OVER/PROGRAMMING COMPLETE; EXPECTED ATE SHUT DOWN UPGRADE - 2 TO 4 WEEKS
75	GTF FUNCTION - SET UP UPGRADED TEST FOR OP 220	B/M	V/PE	2/5	207.0	H/S-U C/O-C
76	CHECK NOISE - SET-UP UPGRADED TESTER FOR OP. 225	B/M	V/PE	2/5	207.0	H/S-U C/O-C
77	COMPENSATE PHASE & TORQUE SET-UP UPGRADED TESTER FOR OP. 325,330	B/M	V/PE	2/6	471.6	H/S-U C/O-C
78	SET-UP UPGRADED TESTER FOR OP. 345	B/M	V/PC	2/6	207.0	H/S-M C/O-C
79	SET-UP UPGRADED TESTER FOR OP. 373	B/M	V/PE	2/6	207.0	H/S-M C/O-C
80	SET-UP UPGRADER TESTER FOR OP. 3785	B/M	V/PE	2/5	207.0	
81	INSTALL CNC NOTCHER (WS 8)	B	PE/FC	2/3	3738	
82	SET-UP MISC. CELL*1 (WS 10)	B/M	PE/FC	2/1	4.14	
83	SET-UP MISC. CELL #2 (WS 11)	B/M	PE/FC	2/1	5.7	
84	SET-UP POTTING CELL	B/M	PE/FC	2/3	2.07	
85	INSTALL INJECTION MOLDG. EQUIPING (POTTING CELL)	B	V/PE	2/2	16.1	UPGRADE STATIONS; CHANGE OVER COMPLETE
86	SET-UP/UPGRADE BURN-IN-AREA	B/M	PE/FC	2/16	98.33	F/A - LINE
87	IMPLEMENT ADVANCED TOOLING ALL OF F/A	M	PC	3/8	163.93	RG/REPAIR AREA
88	SET-UP/INSTALL ADVANCED TESTERS CHECKERS	B/M	PE	2/12	80.98	ALL OF F/A
89	INSTALL REMAINING SMALL EQUIPMENT	B/M	PE/FC	2/7	82.57	
90	INSTALL SHOP WORKSTATIONS/FURNITURE	B	PE/FC	3/4	57.98	
91	REPLACE OFFICE FURNITURE	B	PE/FC	2/1	17.37	
92	INSTALL VS/RS (TEARDOWN-AREA)	B	V/PE	2/3	16.68	VS/RS TEARDOWN A
93	COMPLETE F/A-INSTALLATION	M	PE/FC	5/25	29.0	
94						
95	GENERAL: ALL OF GG1111					
96	INSTALL BARCODE SYSTEM	B	V/PE	2/20	40.70	
97	INSTALL SHOPFLOOR CONTROL SYSTEM	B	V/PC	3/30	RICHARD	
98	INSTALL CAPP SYSTEM	B	V/PE	2/24	RICHARD	
99	INSTALL CRT'S (SHOP)	B	V/PC	2/4	40.25	
100	INSTALL CRT'S (OFFICES)	B	V/PC	2/2	28.24	(INITIAL INSTALLATION & PILOTING PRIOR TO STEP II IMPLEMENTATION - PRIOR TO JAN 89)
	SUBTOTAL/TOTAL				848	

LEGEND: M Make; B Buy; V Vendor

FC - Facility Construction; PE - Production Engineer; PC - Production Control

QE - Quality Engineering; H/S U - Hardware/Software Upgrade; C/O-C - Change Over Complete; * Includes Contingency 15%

(Second Step Implementation Events Only)

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Figure 15.9. Implementation Events: Details Step 2 GG1111 Implementation (Final Assembly)

Construction of the new area will occur after existing walls, ceilings, and other building obstructions have been removed. New walls, ceilings, floors, cleanrooms, and utilities (e.g., power, water, gas, heating, and air conditioning) for the "To-Be" factory will be constructed as outlined in the implementation plans.

As additional funds are made available, Implementation Phase III will continue on the other three product areas as outlined in the PCI Master Implementation Plan. Since one product area is considered a coherent unit, no distinction is made between the buffer and assembly areas with respect to the facility.

Step 1 Move ("As-Is" Factory)/Implementation

This is considered the first implementation step of Phase III and consists primarily of moving existing equipment and tooling to the intermediate facility. The processes basically remain "As-Is" and major portion of the facility do not resemble the "To-Be" factory, since more and larger equipment must be place in it. At this time only the outer shell of the intermediate facility resembles the new factory footprint.

Piloting and Finalizing the "To-Be" Processes

A large portion of time, for the time frame prior to Step 2 implementation, has been put aside for piloting and testing the numerous proposed new processes. This is considered one of the most important activities of the implementation, since the level of modernization which can be achieved is directly proportional to the effort and success of this task. All three implementation plans call for time frames of one to one and one-half years to accomplish this task. "To-Be" processes are piloted by area with each area being executed independently. These tasks must be completed and finalized before equipment and tooling can be procured.

Piloting and Finalizing the "To-Be" Controls and Systems

Systems and controls will be piloted and tested. A final decision will be made in parallel with the piloting and finalizing of processes and technologies. Since systems and controls are complex tools, and in the case of this project consist of several subsystems, this activity cannot be emphasized enough. The subsystems [e.g., the Work Center Manager (WCM), the Factory Data Collection System (FDC), data storage, and a CAD/CAM based "Computer Aided Planning Process" (CAPP)] must be coordinated and piloted with the Industrial Automation Systems Division (IASD) in Phoenix as well as with the first user, Honeywell's Space and Strategic Avionics Division (SSAvD) in Clearwater, Florida.

After a successful piloting effort and finalization of system requirements, the new and proven manufacturing and process data (e.g., finalized "To-Be" summaries and details) must be input to the new systems. The implementation plans emphasize that a major piloting effort for systems must be connected with GG1111 Phase III implementation.

Design and Finalizing of Equipment and Tooling

Final design of equipment and tooling can be started after successful completion of piloting tasks.

Design Documents - Based on Honeywell's specifications, which reflect the piloting results, the suppliers of various pieces of equipment will develop design documents as required for final pricing and approval. These documents will include functional design, diagnostic procedures, wiring schematics, application procedures, software, maintenance manual, and other vital information.

Detail Specifications and Drawings - The detailed specifications and design/installation drawings will be prepared by the supplier and approved by Honeywell.

Acceptance Test Documentation - Acceptance test documentation will be developed based on the requirements of the original Honeywell specifications. The acceptance test for major and/or complex equipment will be performed by the supplier prior to shipment of the equipment.

Tooling Design Documents - Tooling drawings will be developed by the MAvD/IIO Tool Design department based on the specifications and requirements developed during the piloting tasks. Tool design will develop drawings of fixtures and general tooling as required for final costing (Fab Fac) and approval. Tooling to be used in conjunction with the new equipment must be designed so that it can effectively interface with the new equipment.

All tooling will be priced/estimated by Fab Fac (or outside vendor for equipment-related tooling) for approval by the PCI department.

Finalizing/Procuring of Hardware and Software

After successful completion of the piloting tasks for systems and systems related hardware, the system software and hardware can be finalized and approved. The supplier will generate the system software packages necessary to operate and control the new factory.

System Software Customization - The supplier will customize the system software to meet the unique requirements of Honeywell's new factory and will interface with the currently installed MRP II (HMS) computer system.

System Integration at the Supplier's Facility - The supplier will integrate the system hardware and software at his facility prior to shipment to Honeywell.

Software Demonstration at the Supplier's Facility - The supplier will demonstrate the system hardware and software to Honeywell personnel for approval at the supplier's facility prior to shipment to Honeywell.

Procure Hardware Components - Based on the Honeywell specifications and the supplier's detailed drawings and specifications, orders shall be placed for procurement of the necessary host computers, terminals, engineering workstations, and necessary network hardware.

Mechanical and Electrical Installation of Hardware - All host computers, terminals, engineering workstations, and necessary network hardware associated with the new "To-Be" factory shall be installed mechanically and electrically in the specified locations in the Stinson/Ridgway facility. The installation will be in accordance with the detailed installation drawings and under the direction of a full time installation supervisor assigned by the supplier.

Mechanical and Electrical Integration of Systems Hardware and Related Equipment - Once installed, the various components of equipment and hardware shall be interfaced with the HMS system so that the new factory can function prior to finalizing the Step 2 implementation.

Operator and Maintenance Training - During the integration of the hardware, the software, and the operating system, both maintenance and operating personnel will be trained on the maintenance and operation of the system.

System Acceptance Testing - The complete system will be operated to perform all of the functions required in the Acceptance Test Documentation.

Final Acceptance - Based upon the satisfactory performance of the complete system against all of the requirements of the Acceptance Test Documentation, the system will be accepted by Honeywell and the warranty period will begin.

Finalizing/Executing a Training Program

Upon completion of the piloting activities and finalizing of "To-Be" processes, equipment, tooling, technologies, and manufacturing practices for the new "To-Be" factory, a comprehensive training program (see Figure 15.10) will be developed. The individual implementation plans highlight the various time frames for executing these vital training programs. The training extends in all of the line, staff, and management levels and will cover all of the necessary facets of the new "To-Be" factory.

TECH MOD TRAINING REQUIREMENTS

ASSUMPTIONS

1. Use "As-Is" headcounts for training estimates ["To-Be" ~ 1/2 "As-Is" but product volume doubles so "To-Be" = "As-Is" count.]

2. All people (management, supervision, engineers, production control, operators, inspectors) will receive 25 hours general training:

   - Work Center Manager
   - Paced Assembly Line
   - Tech Mod Concepts

3. Operators and inspectors will receive additional training (over and above what is now required) relative to their specific jobs. The amount of this additional training will vary depending on individual job complexity. This will include off-line training using video tapes along with off-line work on hardware. This also may include on-line training with another operator and perhaps a designated trainer.

   The above training estimate applies to newly assigned people. For operator already working on the line at the time the new factory is installed, required training will be 75% times 64 hours for a total of 48 hours.

COST TO TRAIN NEW PEOPLE ASSIGNED TO PCI

Newly assigned operators will receive 25 hours general training plus a additional 64 hours job specific training for a total of 89 hours for each newly assign person.

Figure 15.10. Tech Mod Phase III Training Requirements

Step 2 ("To-Be" Factory) Implementation

This is the second and final step of the Phase III implementation and extends into modifying the facility to the final configuration of the "To-Be" factory. This involves the installation of material handling systems, including:

- Automated Guided Vehicle System (AGVS)for inter-area material handling;
- Conveyor systems for material movements in assembly areas and the buffer;
- Pneumatic tube systems for intra-area material movements (in and between product areas)

Modular workstations also will be installed along with new equipment and tooling, particularly the modified ATE's. All implementation activities for transforming the facility to the final "To-Be" factory come to a close in this nine month time window. The various detail implementation activities for the second step are shown in Figures 15.7 through 15.9. Since the new factory is comprised of four modernized product groups, these activities are repeated for the other product groups in the same manner. Training activities are executed throughout the entire Step 2 implementation effort and are coordinated with the other tasks.

Fine Tuning of the "To-Be" Factory/Validation

Throughout the second step of the implementation, equipment, tooling, processes, and systems are fine tuned by the designers of the new factory and by other line and staff personnel in order to achieve the level of performance which is required for the validation of the implementation and completion of the modernization program with General Dynamics and the Air-Force.

SECTION 16

PROBLEMS ENCOUNTERED AND HOW RESOLVED

Problem: Current layout of production units in the Stinson/Ridgway facility would not accommodate the IIO Tech Mod projects or the orderly expansion of the Ring Laser Gyro area.

Solution: The first floor of the Stinson/Ridgway production area had to be re-planned. Management approval of the revised plan was secured.

Problem: Pre-approval of the Cost Benefit Analysis was deemed necessary to successfully complete deliverables on time.

Solution: Developed methodology and reviewed it with General Dynamics in order to gain the approval.

Problem: Ten year market forecasts by product type were not available.

Solution: The Tech Mod team, together with the Marketing and Contracts groups, had to prepare ten year forecasts by device type and customer in order to prepare an accurate Cost Benefit Analysis.

Problem: Labor resource codes identified in the Phase II proposal were not available or were changed during Phase II development.

Solution: Program re-direction had to be re-negotiated to resolve the labor resource code issues.

Problem: Project 51 (PCI Assembly) and Project 52 (PCI Quality) were negotiated as separate projects in the Phase II proposal. Segregating savings by project proved to be impractical as the Cost Benefit Analysis was developed.

Solution: Program re-direction was negotiated to combine the two projects into one Final Report and Cost Benefit Analysis.

Problem: Vendors were reluctant to provide quotes on some automated test without individual detailed requirements specifications.

Solution: Two generic sets of requirements were specified to cover the total range of test complexities to be addressed.

Problem: The "To-Be" factory involves installation of a large, complex customized computer system. Quotes for such a system can only be made against a set of detailed requirements.

Solution: A User Requirement Specification for a similar installation was revised to provide the required, detailed User Requirement Specification for Project 51/52.

SECTION 17

AREAS FOR FUTURE CONCERNS/DEVELOPMENT

- HMS/BOS (Honeywell Manufacturing Systems/Business Operating System) does not have a module to control Work-In-Process in a repetitive environment. Some software development will be necessary to meet the implementation plan. All systems reviewed require some modification in order to meet Tech Mod requirements.

- Other MAvD needs could change the level of capital or resources committed to the Implementation Plan.

- Material Handling at the Stinson/Ridgway building, Project #21, was put on hold until the completion of the production projects and the final floor plan for the building. This area will require future development.

- Significant market increases in the Miscellaneous product work group would require that the Phase II study be resumed at Preliminary Design.

- Significant changes in the Local 1145 hourly union contract could enhance implementation capability. Examples are turnover, work rules, jurisdiction, etc.

- Timely, successful implementation will require dedicated teams organized by product work group.

- Successful implementation of the HMS/BOS system is vital to successful implementation of Project 51/52.

- Successful implementation will require a great deal of education, for customers and vendors alike, on program savings/rewards.

APPENDIX A

TO-BE GG4400/GNAT SPECIFICATIONS/REQUIREMENTS

TASK 2.1.1.2: PRELIMINARY SPECIFICATIONS/REQUIREMENTS FOR "TO-BE" FACTORY (GG4400/GNAT - ASSEMBLY GROUPS)

FEATURE DESCRIPTION/SPECIFICATION

LAYOUT/AREA/WORKCENTER DESIGN

The "To-Be" factory will consist of one final assembly line for each of the GG4400 & GNAT gyro groups. The built-in line flexibility will allow the assembly of todays know GG4400 & GNAT gyros without additional set-ups or rearrangements of the assembly line.

Each of the above assembly areas will be divided into dedicated/common final assembly and subassembly lines. The lines will use common cycle times and scheduling and will use a buffer interface area (joining link) between subassembly & Final Assembly (1 day buffer - also used as; line kitting, general cleaning and parts verification point, final inspection, temporary storage, and some material preparation.

The subassembly area will be divided into the lines for gimbal assembly, pickoff housing and miscellaneous subassemblies - lower level subassemblies/activities will be integrated and be part of the respective final or subassembly line activities.

The buffer and interface area will be located between the GG4400/GNAT subassembly and the final assembly area, and will be used as kitting, parts verification, final inspection, parts preparation and cleaning area for final assemblies and subassemblies. Additionally it will be used as one day material buffer between the final assembly and the subassembly lines and Fab Fac & Stores and so smoothening out irregularities between the lines. The buffer will act also as traffic control point between Fab Fac, IIO Stores and PCI.

Support service personnel directly supporting the various lines like: PE's, PC's, QE's/Inspectors and others, will be grouped into line teams and be co-located (office) with production located adjacent to the respective lines/areas. They are as a group (including production) responsible for the success and profit of their respective product line.

The GG4400/GNAT facility layout will meet modern factory design standards and esthetics and will be guided by the goal for high efficiency for operators and equipment and the image of a modern and well run factory (show case).

Operations which are sensitive to contamination will only be performed in clean environments (cleanroom or local clean air containment, as required) so guaranteeing product quality and minimizing cleaning operations. Less sensitive operations will be performed in air conditioned and/or humidity controlled environments are required.

The cube space (height) in the assembly area will be optimally used to increase 2-D space availability (foot print) and so allowing for a more generous layout of all assembly lines.

Floors will meet cleanroom/work area and ESD-requirements where required and needed.

The bearing assembly remains a supply function to PCI, and will at this time not be integrated into the "To-Be" assembly area -- it will remain separated and only loosely connected to the assembly area. It will upgrade its bearing, final test procedures and required test equipment to reduce gyro yield losses caused by bearings (the group proposes a separate Tech Mod project for modernizing the bearing room and its activities). It will be downscaled to the capacity requirements of IIO/PCI. Bearing assembly will adhere to the J.I.T. material supply philosophies for the assembly lines and be closely interfaced with other parts of PCI (especially the motor subassembly area).

The proximity of areas of each other will be chosen for best optimization of material movements and travel distances. Material handling will be kept to a minimum.

WORKCELL DESIGN

In general, assembly/subassembly lines and workstations will be laid out as dedicated areas/centers/cells, not sharing equipment, tools nor fixtures with other areas (exceptions: laser welder, laser balancer).

Each workstation/cell will be equipped with tooling or equipment necessary to perform the sum of steps or processes as defined by the specific line cycle.

Workstations/cells will typically be equipped with CRT terminals (including bar code reading units) which will be used as receivers or input stations of process and production related data. Goal: elimination of paper layouts and paper input sheets (recording).

Workstations/cells will be laid out with only tools and fixtures shown on layouts and processes. Other tools and equipment is banned from these workstations. (PE's are responsible to keep the workstations efficient.)

Workstations/cells will be equipped with individual lighting where general lighting is inadequate and will meet the lighting standards for this kind of production.

Workstations/cells will be ergonomically designed for improvement of the overall productivity and are based on modular building units for easy adjustment to particular workstation/cell requirements and configuration. Workstation/cells will be uniform in design and will contain elements required for the cell design. The color of workstations/cells will be chosen for improved esthetics of areas and to create openess and a relaxed/productive atmosphere.

The design of workstation layouts (micro layout) will be based on application of industrial engineering (IE) rules and techniques (like motion study, ergonomics, capacity, etc.). workstations will typically be supplied with electric power, computer hook-ups (for CRT terminals), air (as required), vacuum (as required), and other utilities as required to meet specific applications.

FACTORY DESIGN DATA

The capacity will be based on a 2-shift 8 hours/shift, 5 day/week (2/8/5) operation which will amount to 4,000 available working hours per year.

Final assembly and subassembly lines will be designed for a standard batch size of "one".

The subassembly/assembly line design will be based on streamlined/consolidated "To-Be" factory baselines with cleaned up and improved processes - meeting PCIs goals.

The subassembly/assembly line designs will be based on a (cleaned up) 85% productivity rate (productivity = efficiency x operator/equipment utilization).

The assembly lines (both subassembly and final assembly) will be laid out based on a true (cleaned up) 99% product yield rate, with a later improvement to 99.5% (2nd year).

The layout design will allow for adequate space surrounding the workstations and equipment and will apply ergonomics factory standards; aisle space will be tailored to the specific need of areas and assembly lines and in general will be kept to a minimum.

- Typical workstation/space requirement = 50-60 sq. ft.
- Typical aisle space/width-low traffic area - 4 ft.
- Typical aisle space/width-high traffic area = 6-8 ft.

openness
A factor of 20% will be considered in all areas for future expansion.

Ceilings will be suspended (if needed) to meet a 12 ft. ceiling height (energy usage).

The standard size of workstations will typically be:

- 2'x4'x5' for workstations with manual operations not requiring bench top equipment.
- 2.5'x5' for workstations with bench top equipment/tools.
- special designs/sizes for special workstations ("To-Be design)

After implementation and set up of the "To-Be" factory, the assembly and subassembly lines will be starting up with line cycles above the standard to allow for learning curve effects (which allow operators to develop the revised skills and dexterity necessary to produce quality products in the "To-Be" factory) and to allow support service teams adequate time to streamline and debug the assembly lines and the "To-Be" manufacturing system. The standard cycle time for reaching the learning curve goal of 80 to 85% (to be set by PCI).

MANUFACTURING PHILOSOPHIES/CONTROLS

The final assembly and individual subassembly lines will be balanced and paced so allowing continuous and predictable line output/capacity, which will be based on common cycle times and line schedules. Computers and advanced computer systems will function as controls replacing manual systems.

Line cycles/cycles are generally defined as multiples of related or subsequent operations or process steps within one workcell, they have to be performed within this timeframe (deficiencies and yield losses considered). NOTE: The sum of steps/operations can be shorter but can't exceed the standard cycle time (utility/relief personnel required for continuous flow).

The line flexibility of the GG4400/GNAT "To-Be" assembly area will be designed such that product mixtures of todays known GG4400/GNAT gyros (as designed into "To-Be" factory), and gyro designs meeting these lines requirements, can be assembled without loss of productivity, nor creating bottlenecks or requiring additional set ups or schedule modifications -- later added gyro types must follow the "To-Be" standard process criteria and requirements in order to meet the productivity goals.

Low quantity production or gyros not fitted for standardization (major requirements required for the "To-Be" assembly line) such as: major repair, RG's spares, field returns or developmental gyros, will be produced off-line in a low quantity production or pilot area (minimize/eliminate choking and inefficiency of line).

Operations which are a part of the process sequence to complete assemblies and subassemblies, will be performed on-line also and will not leave the assembly area unless the assembly is completed (on off-line operation within the line flow - no interruption).

All parts/assemblies will be bar coded before they enter the "To-Be" assembly lines (small parts which are too small for bar code ID labels are put into container/cases/pouches etc. with bar code labels attached to it). In general, barcode labels are not attached to the bare part/assembly if it will contaminate the part surface or is not acceptable.

Parts will enter the assembly/subassembly lines only as completed kits meeting the BOM - buildup (no waiting for parts), since the "To-Be" leadtimes (reduced) require that parts/assemblies are available and used within short time frames, mostly in less than one or two shifts. C-parts will be stored at each of the respective workstations/cells for immediate use.

If parts-shortages/missing parts occur at control points (in buffer area), the respective line will be rescheduled (through computer, not manually) whereby the next available and complete assembly kit will take first place in the scheduled sequence. The delinquent kit will enter the line only after the parts-shortage is resolved. The (now complete) kit will then be rescheduled again with the highest priority. Parts shortages will be flagged and monitored electronically, aiming at minimizing/eliminating parts shortages in the future. Schedule changes will effect all downstream operations of a line or stoppage point combination of line as they are interfaced.

Major line problems which could effect more than one assembly line will be handled through line shutdown of the respective line(s) and so triggering the elimination of the problem permanently no band-aid solution). Line-downs will be flagged through a "red-down alert" light of the respective line on the computer screen and the line control point, and through a flashing light at the problem area. Line-downs will show up on CRT screens (for supporting personnel and management) as a flashing signal and/or audio signal.

To minimize/eliminate equipment downtime which is essential to meet expected line goals (100% uptime in 2 shifts), PCI will introduce and install preventive maintenance programs (planned and scheduled, not sporadic) and will keep supplies of critical equipment/tooling parts on hand (no shut down during working hours; maintenance in 3rd shift or other off-hours).

Work-in-process levels (WIP) will be reduced to amounts of material which are only contained in the assembly lines (line fill) which will be a fraction of todays WIP, and the amount of WIP which is contained in the one day buffer area.

The philosophy for supplying the GG4400/GNAT assembly lines with parts and material will be based on "Just-in-Time" (JIT) philosophy whereby material will be ordered/supplied only when needed and with the shortest time delay possible, controlled only by the master schedule and line output.

The individual assembly lines will be equipped with visual (digital) displays at the end of each line, displaying the count of units produced (by day/year) and comparing it with the units planned. The displays will be used as indicators of line output and performance, and as group incentive for operators.

PROCESSES/METHODS/TECHNIQUES

Parts/assemblies will thoroughly be cleaned and, (if so required by process) and hermetically sealed before entering the line and assembly process. Redundancy of cleaning operation will be reduced to justifiable exceptions only (special specifications).

Machining operations/processes as performed by FAB FAC and vendors, which are essential and critical for continuous line flow will either be performed in-line to the respective station or adjacent to it. They will adhere to the same schedule.

In general, equipment and tool setups on lines will either be negligible or zero. If set-ups are not avoidable or required, the design will apply automation where possible to free operators for value added operations or will use specialized equipment.

Process instructions used by operators and other personnel, will be simplified and rewritten and exhibited to the workstation in a understandable, clear written language, addressed to production operators and non-engineers. Graphics/pictures and assembly drawings will be used extensively so allowing less skilled or/experienced personnel to grasp tasks and successfully produce a better product. Processes must be proven and solid and must successfully be repeatable before they can be implemented on the line (not laboratory level processes).

Operations with process times which are extensive and multiples of cycle times like: bonding, curing, filling, burn-in, run-in, balancing, etc. and which don't require operator attention during the entire process, will be integrated to assembly lines in the form of continuous turrets/carousels and so adhering to the same product build sequence and the line cycle as the remainder of the line(s).

Operations like testing, soldering, cleaning, bonding and bonding preparation, machining, etc. will be integrated and performed in the "To-Be" factory as part of the assembly line operation (dedicated) adhering to the same standard cycle as the remainder of the line. Laser welding and laser balancing and winding are considered central operations and located such that users have easy access.

QUALITY/QUALITY SYSTEMS

A total quality control (TQC)philosophy will be the base for and to guarantee the quality of products and excellence in workmanship. Parts and assemblies not meeting quality standards and specifications will not be passed on to the next workstation/cell (no cumulation of failures/rework further down the line), but corrected immediately and only passed on after the problems have been resolved.

Operators are responsible for their in-line inspection/frequent checks of their particular process and work - final inspection will remain the responsibility of Q.A./inspection and be performed mainly in the buffer area or at appropriate locations or points where necessary (minimization of Q.A. inspection). Final inspection will follow the same line cycle as the paced assembly line.

The final inspection function will be performed under the control and responsibility of the GG4400/GNAT line management and be considered as measurable cost and time element in cost calculations. (portion of costing/standards/team effort).

Computers, electronics, advanced tools and equipment will be used for quality/inspection related activities in order to meet time and quality requirements constraints on the line.

Verification of incoming parts (second and final screening) will be the prime responsibility of inspection teams operating in the buffer and kitting area. They will be using electronic and functional gauges and instruments where necessary to meet product standards and specifications. Parts not meeting quality standards will not be used in assembly kits in order to minimize/eliminate assembly line breakdowns caused by less than adequate quality.

Long term receiving inspection practices and procedures will be improved and based on revised procedures whereas receiving inspection teams check/audit a major parts at vendor locations prior to being shipped to the plant, thereby guaranteeing that these parts will meet the quality standards and can be used in production immediately (important for "JIT" supply philosophy).

SYSTEMS/AUTOMATION

Critical operations that are marked by low product/process reliability, (low yield rates), or are potentials for bottlenecks and operator fatigue, will be prime areas for automation (decision on individual basis).

Products will be continuously monitored and controlled throughout the entire assembly process, (from the moment they enter a line until the finished product leaves the last workstation). The system which will be used will be based on total physical parts control. It will be based on real time and will use a bar code identification system for feedback. Each of the workstations/cells will be equipped with bar code readers, which will be linked to the system and the main computer thru networking techniques.

GG400/GNAT assembly lines will be scheduled and controlled by a master schedule only (production control/systems) and only limited by the available and built-in line capacity, (output of the last workstation/cell in the final assembly line).

The scheduling and control system of all lines will interface with the HMS/MRPII systems of IIO - which will be the primary system for higher level activities.

Workstations/cells will have visual/audio-alert/help elements (flashing light etc.) to indicate production problems or line breakdowns. Management and support service computers will also be interfaced with this alert system. Problems will be displayed as flashing fields on the screens (showing the troubled work cell and breakdown code) and so alerting building support personnel to the troubled workcell.

A computerized dispatch/control center will be located in the buffer area and be operated by experienced/production control personnel. The dispatch/control center will be the only area responsible for preparing and releasing assembly kits to the line(s).

Computer and reporting systems throughout the "To-Be" factory will be based on real-time operation and set up only.

MATERIAL HANDLING SYSTEMS/SAFETY

Handling of material and parts within final assembly and subassembly will be automated and be paced to the pre-determined line cycle intervals, which will be the only pacing element for the continuous and predictable line output (manual handling limited to workstations/cell only).

Kitted parts will remain in protective containers throughout the entire assembly processes to protect parts and assemblies, and as an aid for the completeness of kits at various assembly line processes (parts already cleaned will be kept in vacuum pouches or bags).

The GG4400/GNAT assembly area/buffer will be connected to IIO's Central Stores, by automated material handling systems (part of Project 20). The supply schedule is influenced only by scheduled demand of the assembly lines.

Chemicals, required for certain operations on the line, will be stored in safe and secured locations meeting OSHA/EPA codes. Related operator emergency stations will be located near user points.

Restrooms, vending machines, breakrooms and telephones will either be located inside the production areas or close to it, thus minimizing travel distances and related time losses, which could be critical to the line cycle/speed and lien output.

Parts and material storage will be limited to the buffer area and to some extent to workstations only. The storage system used in the buffer area will primarily depend on automated storage and retrieval system primarily vertical storage systems (VS/RS).

The "To-Be" factory will be designed with a centralized, efficient, and safe trash disposal system, to minimize the danger of parts contamination, especially in clean room areas.

No provisions will be made for the use of lift trucks or the use of handling devices similar to lift trucks. Lift trucks will not be permitted in assembly areas and will only be permitted during the implementation phase of the "To-Be" factory, primarily used for moving heavy equipment.

TRAINING/HUMAN ISSUES

Before operators can qualify for "To-Be" assembly lines, they must complete a training class related to their tasks. This will be prior to their assignments to the various lines or workstations.

To guarantee continuous success in the GG4400/GNAT assembly area and to keep operator spirit up, IIO/PCI will investigate the introduction of an incentive system, based on line performance (output and quality), and be used as an incentive program for the assembly area. It will be designed to foster high performance and continuous output of quality products at all lines.

The "To-Be" factory will apply philosophies and rules in order to keep operators at their workstations/cells for an extended yet reasonable time period, to stabilize workcrews and to get a payback for improved training effort. Within those agreed time limits, operators are not eligible for job transfers or move into other areas (stabilization of line and skill levels/talents). Operators will be cross-trained (within work cells/areas) to counteract line balancing problems, and so improving productivity shortcomings and to overcome absenteeism problems.

MANAGEMENT

Line supervisors and foremen will occupy offices, located adjacent to the (co-located) support service teams and their respective area of responsibility. Line group leaders in assembly areas are less critical to contamination, and will occupy open offices. Group leader offices in cleanroom areas will be enclosed so minimizing the danger of cleanroom contamination.

NOTE; Supervisors and group leaders will be responsible for the success and output of their line(s).