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FORT WORTH DIVISION

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INDUSTRIAL TECHNOLOGY MODERNIZATION PROGRAM

Phase 2

Final Project Report

PROJECT 43

COMPUTERIZED AND ADVANCED QUALITY ASSURANCE SYSTEM FOR THE FABRICATION FACILITY

Honeywell

Military Avionics Division

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This project involves statistical acceptance of fabricated parts in the machine shop. The object is to turn over to production the responsibility of hardware appraisal while Quality will have the responsibility of auditing the system. Auditing will be comprised of checking gaging setup, visually inspecting workmanship, and reviewing data accumulated by the production operator. Electronic equipment will gather data and calculate control charts. This equipment uses stndard gages to read dimensions and electronically transmit readouts to a microprocessor for determining acceptances. The benefits anticipated are a reduction of total processing time; real-time feedback to the operator on the quality of the process; aid to engineering analysis with the addition of recorded measurements; and a nonquantitative reduction in scrap and rework. Keywords:

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GENERAL DYNAMICS
FORT WORTH DIVISION

INDUSTRIAL TECHNOLOGY MODERNIZATION PROGRAM

PROJECT 43

PHASE 2 FINAL PROJECT REPORT

COMPUTERIZED AND ADVANCED QUALITY ASSURANCE SYSTEM FOR THE FABRICATION FACILITY

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PROJECT 43

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PROJECT 43

COMPUTERIZED AND ADVANCED QUALITY ASSURANCE SYSTEM FOR THE FABRICATION FACILITY

SECTION 1

INTRODUCTION

Project 43 involves statistical acceptance of fabricated parts by inspectors at the machine. The objective of the project is to turn over to Production the responsibility of hardware appraisal while Quality will have the responsibility of auditing the system. Auditing will be comprised of checking gauging set-up, visually inspecting workmanship, and reviewing data accumulated by the production operator.

Equipment is available for gathering data and calculating control charts. This equipment uses standard gauges to read and transmit the dimensions to the microprocessor for determining acceptances.

The benefits of Project 43 are:

- A reduction of total processing time because parts do not have to be transported to the inspection area.
- Real-time feedback to the operator on the quality of this process.
- Aid to engineering analysis with the addition of recorded measurements.
- A reduction in scrap and rework because of improved process control. ITM Project 44 will show these savings.

SECTION 2

PROJECT PURPOSE/OVERVIEW

The purpose of Project 43 is to provide Production operators with real-time statistical data on the control of their machining processes through histograms and `X (Bar) & R' charts displayed at their machines. These process control charts will give the operator real-time feedback on the quality level of the parts being produced. Inspection will monitor the results and make acceptance/rejection decisions. Part flow through the shop will be from machine to machine with part quality being monitored by inspection at each operation.

The project will be implemented in the ITM Project 44 work cells as follows:

- Walnut Cell
- Lamination Cell
- Laser Base Cell
- Girth Ring Cell
- Pallet Cell
- 1 1/2" Bar Cell

SECTION 3

TECHNICAL APPROACH

PURPOSE

The project's primary purpose is to investigate and justify technologies and equipment on system integrations that will meet Honeywell's Military Avionics Division's Quality requirements. The Project approach is in unison with ITM Project 44 but can be implemented as a stand alone project.

The Phase 2 development study analyzed and expanded upon the cost-reducing concepts of the Phase 1 report. It followed the specific requirements of the statement of work.

PRELIMINARY SCOPE

Phase 2 identifies requirements with emphasis placed on the following:

- Measurement devices must have digital display/output.
- Measurement devices must be compatible with data collectors.
- Automated coordinate measurement equipment must have capacity to save inspection results and be able to transfer data to Honeywell mainframe computers.

The system analysis included: parts flow through the shop (interaction with ITM Project 20); Honeywell Manufacturing System (HMS); Process Management System (PMS); Factory Data Collection (FDC) interfaces; Quality Data retention; and configuration control. All Fab Fac Quality Engineers participated in the system analysis review.

As equipment was defined, a pilot was selected to verify the technical feasibility and upward communication to the Information Service Management (ISM) systems. This pilot was established in the Milling Department. The pilot demonstrated all aspects of the final design considerations.

SECTION 4

"AS-IS" PROCESS

PROCESSES

The present system involves Production Engineering, Quality Engineering, and Industrial Engineering to complete a process before releasing it to the floor for fabrication. The Production Engineer develops the manufacturing process to produce the part. A part may contain as many as 15 production operations. Quality then assigns the inspection operation points. These inspection operations are preceded by several production operations. Generally, there are four to six production operations between inspection operations. See Figure 4.1 and 4.2 for the "As-Is" process and workflow.

After the inspection operations have been assigned, the Quality Engineer reviews the production operations and assigns gauges for the operator to use while producing the parts. Inspection instructions are written for each inspection operation, specifying the Sampling Plan and Acceptable Quality List (AQL) for each print characteristic. The Industrial Engineer then applies time standards to production operations but not to inspection operations.

The IDEF in Figure 4.2 shows the relationship between Production Control, Production Engineering, Manufacturing, and Quality Assurance. Production Control provides the routing, operator instructions, and scheduling (Shop Packet) needed to produce the parts according to the engineer's specifications. The Quality instructions are controlled separately and are provided to the inspector through a union person. As the parts are processed through the manufacturing processes, the Shop Packet is used to direct the parts from operation to operation.

MATERIAL FLOW

Parts are fabricated on a lot-by-lot basis. There are no continuous operations. As parts are machined, they are routed from machine to machine until an inspection operation is reached. The parts then are brought into the inspection staging area to be assigned priority for inspection. After completion of inspection, parts are routed through the subsequent operations until another inspection operation is reached. Parts which are rejected at an inspection operation and must be reworked, are routed back to manufacturing for rework. This causes additional delays due to machine loading capabilities.

FABRICATION FACILITY OPERATION

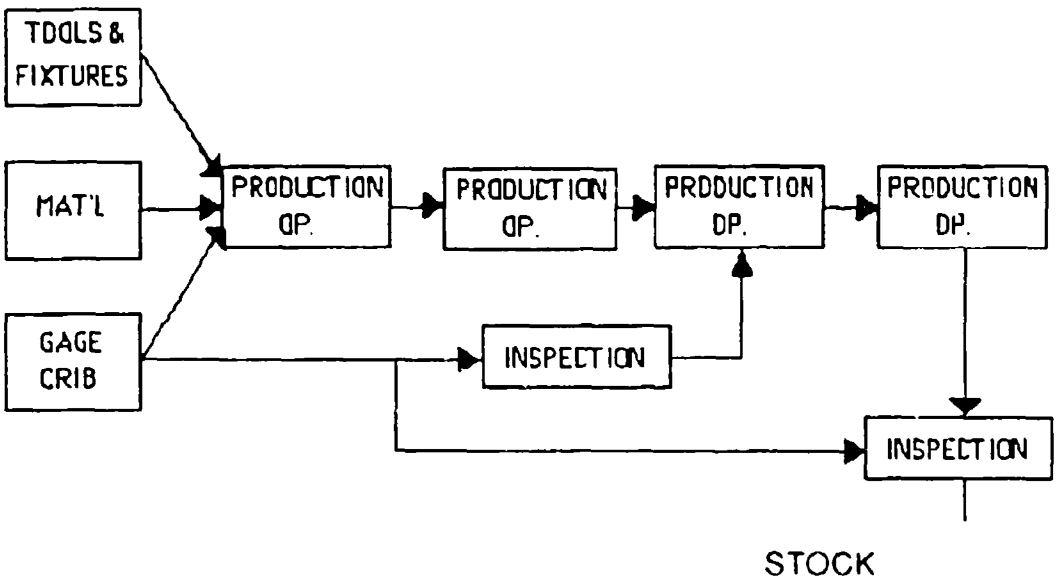


Figure 4.1 "As-Is" Part Flow Process

INSPECTION PROCEDURE

Parts are moved to inspection where they wait for assignment to an inspector through a manual priority system. The priority system is maintained by the inspection group leader. After assignment to an individual, the inspection instruction and history folder are obtained by the inspector.

The inspector first must obtain gauges from the gauge crib as called out in the inspection instructions. After gathering the gauges, history folder, and configuration documentation, the parts then can be checked for conformance to the print.

FACILITIES

The Fabrication Facilities (Fab Fac) are located at the east end of the Stinson/Ridgway building on the first floor. The machining operations are separated into types of operations (Turning, N/C, Metal Finish, and Miscellaneous). The Inspection Department is located across from the end of the Turning Department. See Figure 4.3.

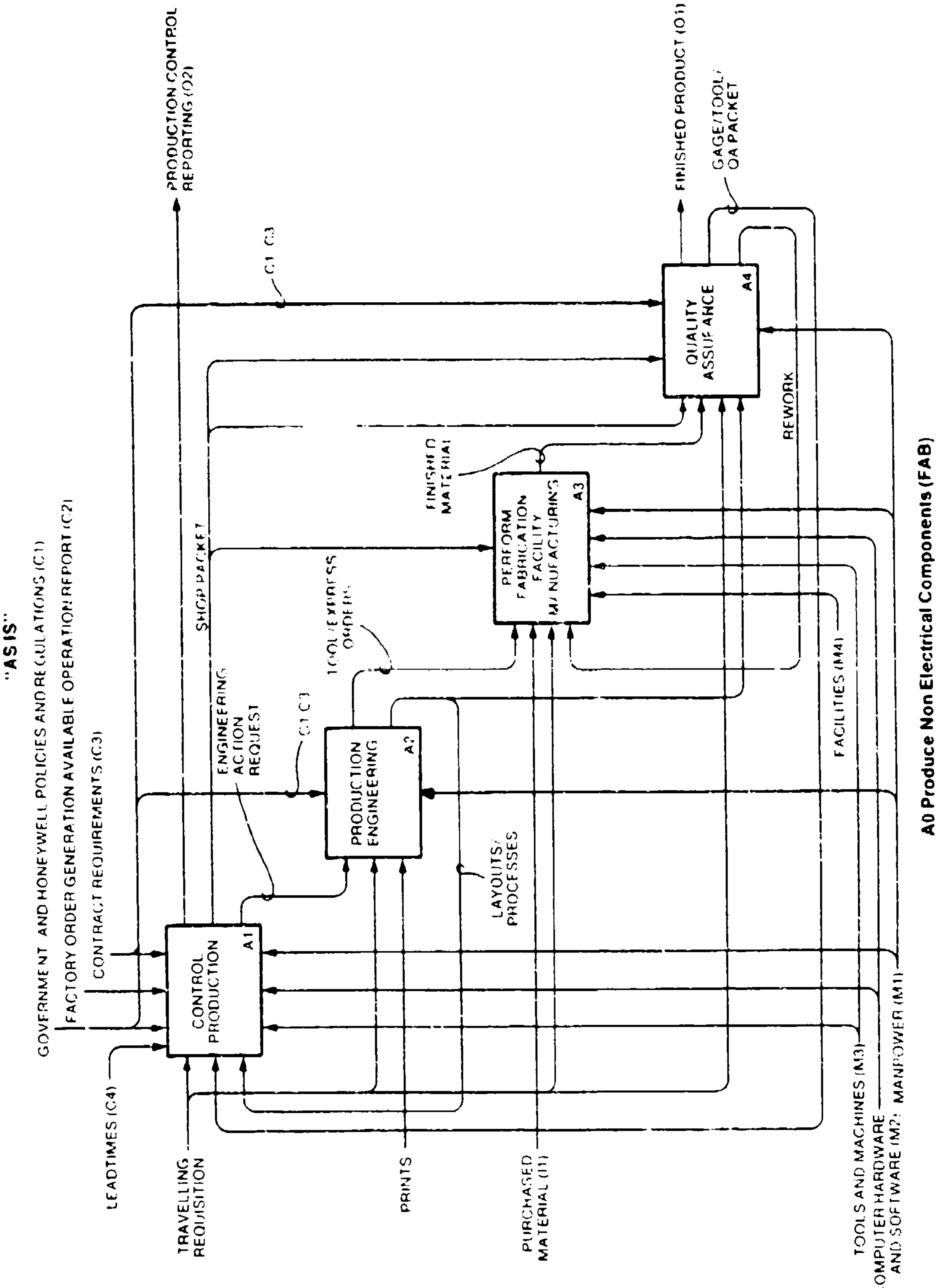


Figure 4.2 "As-Is" Fabrication Facility Workflow Diagram

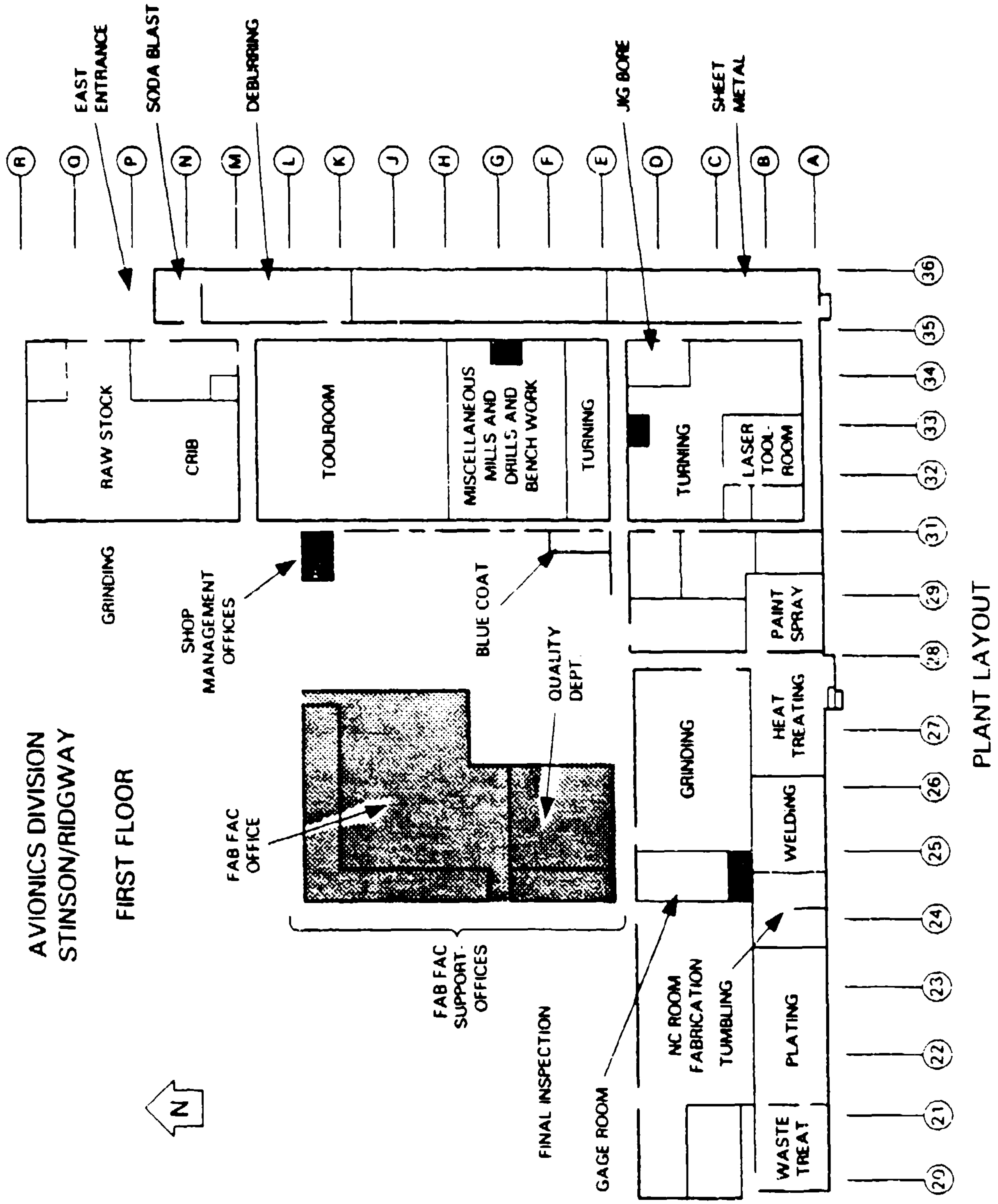


Figure 4.3 "As-Is" Fabrication Facility Layout

EQUIPMENT

The inspection equipment used in the facility includes standard gauges such as plug and ring gauges, height gauges, verniers, micrometers, and thread gauges (see Figure 4.4). There are two microprocessor-assisted coordinate measurement machines in the area. None of the equipment is being used to automatically record acceptance data.

GAGE EQUIPMENT	NUMBER OF GAGES	AGE FROM-TO	AVERAGE AGE	5 10 15 20 25 30 35 40 45
COORDINATE MEASURE MACHINE	2	2-5	3.5	
COMPARATOR	1	18	18.0	
ELECTRONIC INDICATORS	30	1-23	4.5	
MICROMETER VERNIERS	180	2-20	15.0	
PLUG/RING THRED GAGE	5000	1-20	10.0	
HEIGHT GAGE	30	10-25	20.0	

Figure 4.4 Fabrication Quality Equipment

DISADVANTAGES OF CURRENT SYSTEM

The present system allows parts to be processed through various production operations until an inspection operation is reached. This has some inherent disadvantages. They are as follows:

- Delay of parts to stock due to scheduling through inspection.
- Rework must be scheduled through other machines because set-up has been removed from producing machine.
- The operator who produced the part may not be responsible for the rework due to parts being reworked at another machine.
- Operator corrective action becomes more difficult due to several shifts producing the part.
- Gauge set-up by operator may be wrong due to infrequent use of gauge.

SECTION 5

"TO-BE" PROCESS

STRATEGIC PLAN INTERFACE

The Division's ten year plan for Quality is to improve the quality of parts/devices being produced by Inertial Instruments Operation (IIO), decrease delivery time, and reduce cost. Project 43 proposal meets the Division's future needs by use of statistical process control, better utilization of manpower, and reducing the throughput times. Figure 5.1 and 5.2 shows the "To-Be" processes and workflow.

OVERALL SUMMARY

As part of the new system, Quality Engineering will include the inspection requirements and procedures to be followed for each production operation. These requirements and procedures will be a part of the production detail instructions. Production Control will still provide the routing and other information as noted in the "As-Is" discussion. The production operator will check parts according to the Quality Instructions of the detail operation instructions.

The gauges will all be digital displays with electronic output connected to a microprocessor for gathering the data. The measurements will be used by the unit to calculate the standard deviation for the sample. The unit then displays either an 'X(Bar) & R' chart or a histogram for each variable characteristic.

The inspector will perform an audit as outlined by the Quality Engineer. As a minimum, the audit will include a review of the statistical charts coupled with a review of the attribute data. The summary data then will be uploaded to the mainframe computer to meet the criteria of acceptance evidence. The inspector will place the necessary stamp on the move order to permit parts to be moved to the next operation or to stock.

PRODUCTION INVOLVEMENT

Quality will furnish the production operator with gauges for checking the variable measurements. Using gauges is not new to production operators. They currently check their parts, but do not record any findings. The gauges will all have digital displays with electronic output going to a data collector. The number of parts the operator is to check per shift will be identified in the production instructions. The operator will have time to check the dimensions during the machine cycle time.

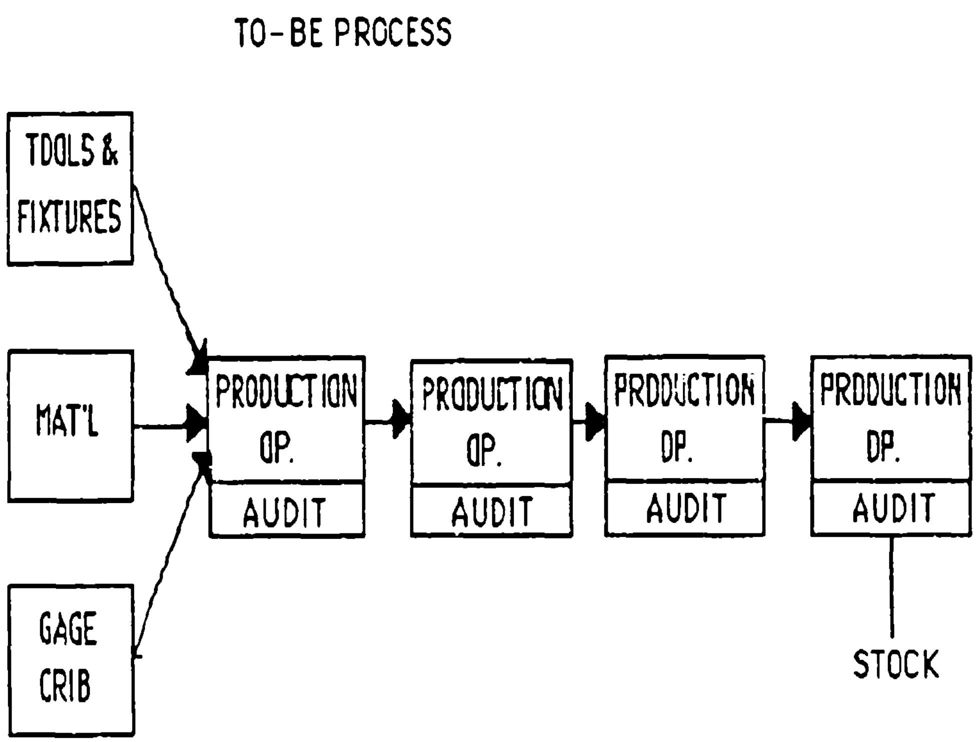


Figure 5.1 "To-Be" Parts Flow Process

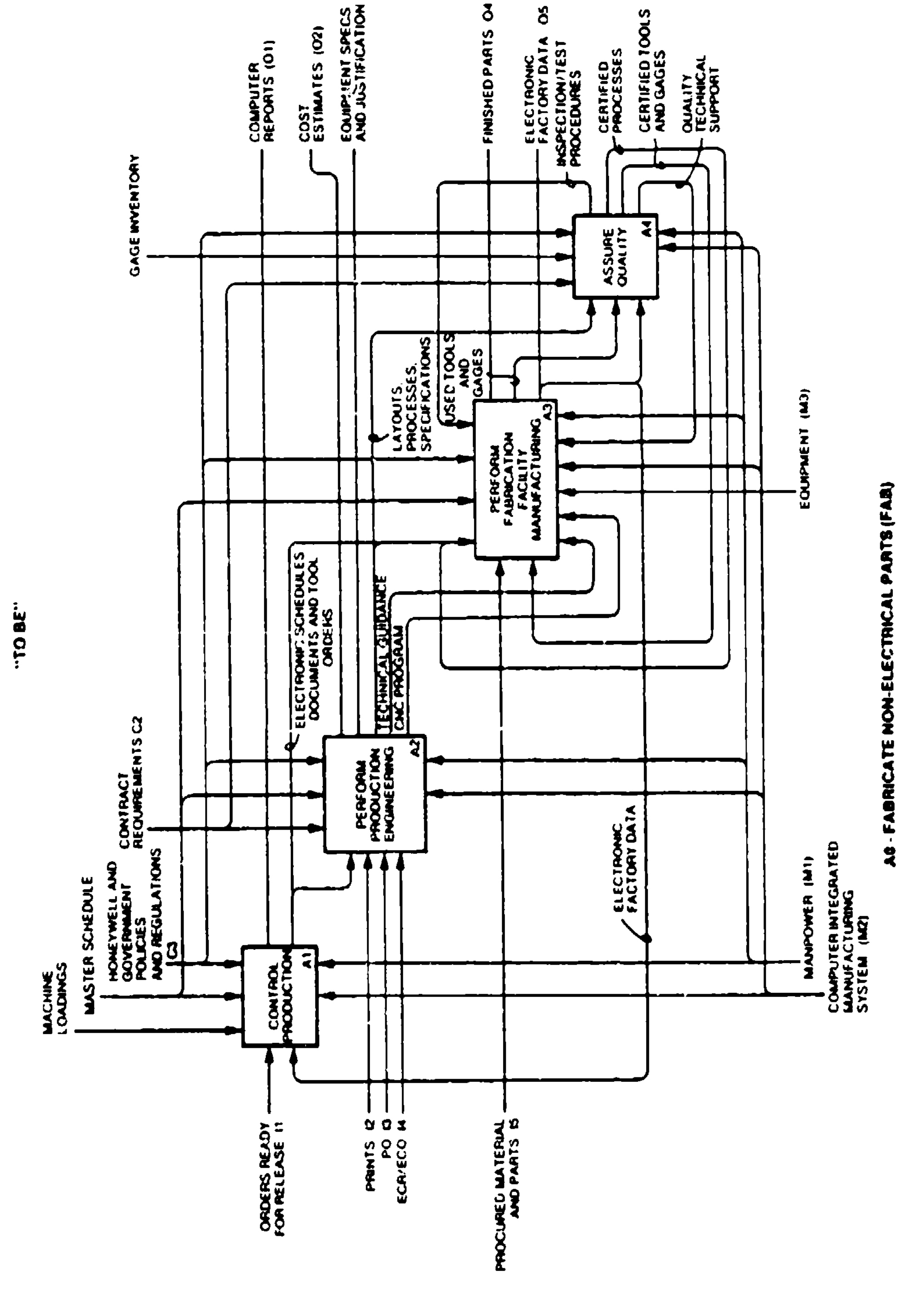


Figure 5.2 "To-Be" Fabrication Facility Workflow Diagram

PRODUCTION ARRANGEMENT

The factory will be rearranged as shown in Figure 5.3 and detailed in ITM Project 44. The individual work cells will be furnished by ITM Project 44 and will allow room for the necessary gauging equipment and its associated data collectors. The floor space to allow the implementation of this project is also being allocated by ITM Project 44.

ANTICIPATED PROJECT BENEFITS

- IMPROVED QUALITY
  The quality of the parts are expected to improve through the use of statistical analysis.

- REDUCED THROUGHPUT TIME
  A reduction in the time it takes to process parts through the factory will be reduced by the amount of time parts use to sit in the inspection area waiting for inspection.

- REDUCED SCRAP/REWORK
  With the inspector checking the gauge set-up and reviewing the statistical data, it is anticipated to result in a reduction in both scrap and rework.

- REDUCED INSPECTION COST
  Since the inspectors will be reviewing data as opposed to physically checking parts, the time needed to appraise the acceptance of the hardware will be reduced.

- IMPROVED ENGINEERING ANALYSIS
  The data collected during the manufacturing process will be available to both Production and Quality Engineers.

- ENHANCE J.I.T.
  Since parts will be accepted at the machine, the parts can go to the production line without delay.

- FITS ITM PROJECT 44 PLANS
  This project was worked in close harmony with ITM Project 44.

- FITS ISM PLANS WITH HMS, PMS, AND FDC
  The data collection and required record keeping was taken into account while planning the necessary steps in this project.

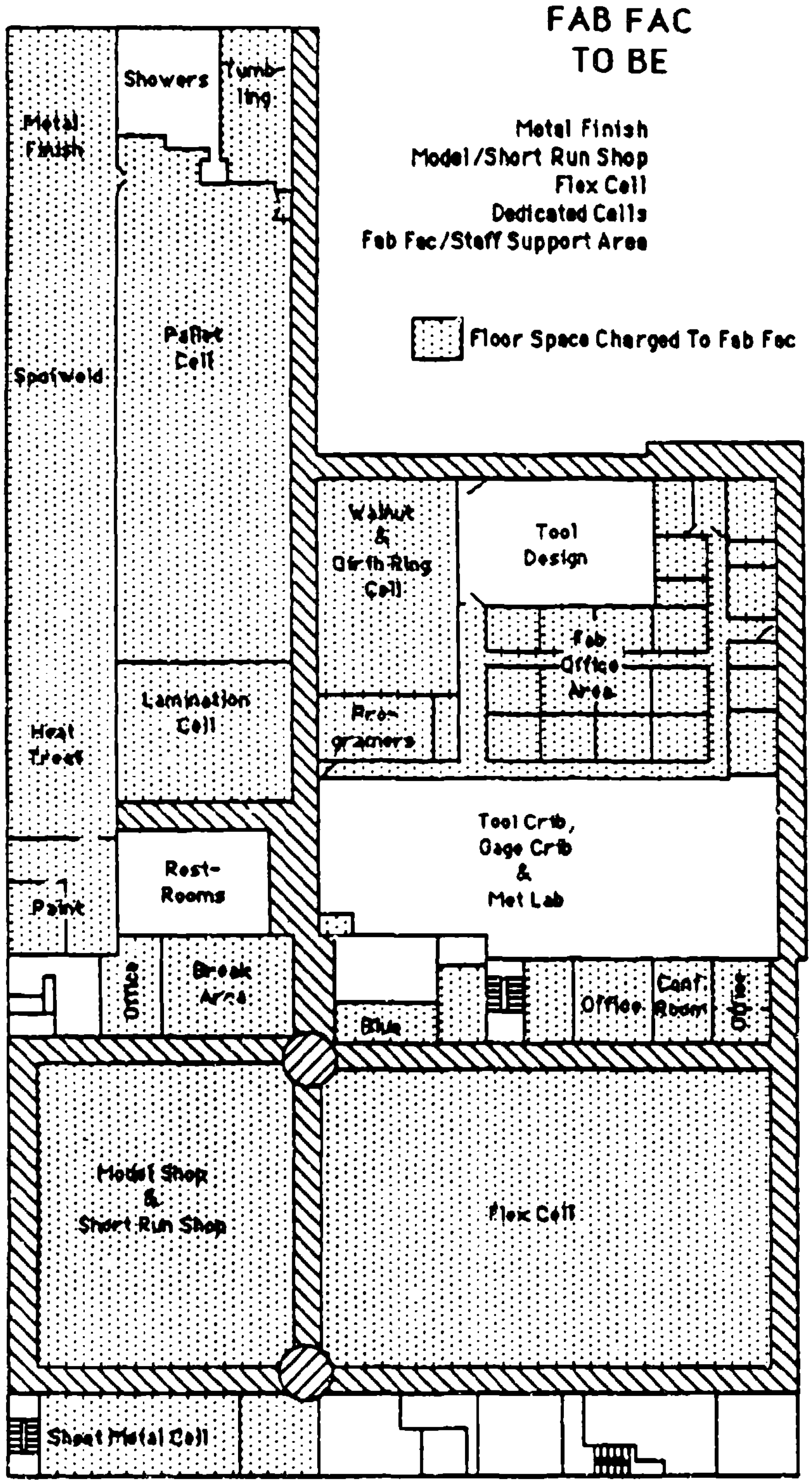


Figure 5.3 Fabrication Facility Proposed "To-Be" Plan Layout

SECTION 6

PROJECT ASSUMPTIONS

The following is a list of project assumptions:

- HMS (Honeywell Manufacturing System) will allow both production and inspection data entry at the same time on a production operation.
- FDC (Factory Data Collection) will provide a means by which historical data can be transferred to the mainframe computer or alternate software can be used.
- Management provides funding and time for training.
- The Union and Management embark on the project jointly.
- The project will be carried out by Fab Fac Quality staff.
- Capital equipment costs are based on 1987 prices and technology.
- Capital funds will be made available when required.

SECTION 7

GROUP TECHNOLOGY CODING SYSTEM ANALYSIS

There was no group technology coding system used in the analysis or proposed in the implementation of Project 43.

SECTION 8

PRELIMINARY/FINAL DESIGN AND FINDINGS

INTRODUCTION

The scope of ITM Project 43 is to provide statistics to production operations which have a work load consisting of a few similar parts or a dedicated process to a similar machining operation. It would be too difficult and costly to provide statistics for all operations in the Flex Shop and Model Shop due to the changing variety of parts in those areas. After ITM Project 44 defined the Work Cells, Model Shop, and Flex Shop, it was determined (cost effective) to apply ITM Project 43 to only the following Work Cells:

- Lamination Cell
- Walnut Cell
- Laser Base Cell
- Girth Ring Cell
- 1 1/2" Bar Cell
- Pallet Cell

PRELIMINARY SYSTEM DEFINITION

The first step in determining the equipment and techniques to be used on each of the work cells was to obtain a list of part numbers from the Production Engineer who had responsibility for that cell. Then each part was reviewed for print characteristics which will be controlled by Statistical Process Control. This ranged from 4 to 10 print characteristics depending on the part process. Parts which had a large number of various tools would warrant more checks then a single pass tool. After this, a list of electronic gauges was compiled. In some cases (1 1/2" Bar Cell) there are common gauges for the different part numbers. In that case, a computer compiled list was sorted to reduce the number of common gauges from 247 to 8 common gauges with 39 special bore gauges.

The Pallet Cell requires two dimensional measurement machines in order to handle the small volume of many lots. Here the equipment selected was an Optical Gauging Product's QSee machine. This non-contacting optical gauging machine will automatically check parts, storing data for future analysis.

Hand held gauges to be used with the data collectors are of many types, but all are electronic with digital displays and electronic outputs for data collectors. Although there are different manufactures, all the gauges are compatible with the data collectors.

FINAL DESIGN

The final design of each of the work cells involved the integration of the gauge requirements and the necessary equipment to perform the data collecting task. The attribute data discussed below refers to workmanship characteristics such as burrs, nicks, dents, scratches, not finished operations, etc.

The equipment selected for data collection from the hand held electronic gauges was the Verax SPC Qualifier. This data processing equipment was chosen because it could perform both variable and attribute calculations and display both types of charts. The Data Collectors will be an integral part of each work cell. They are designed to be mounted on the bench or on the wall. This system also allows uploading of data for history retention requirements. Figures 8.1 through 8.5 shows the work cells where the data gathering equipment will be utilized, as laid out by ITM Project 44.

- LAMINATION CELL

Number of parts 11 Number of collection stations 3 Number of checks 38

Gauges - Height gauge (3)
Bore gauge (3)
Depth Micrometer (1)
Electronic Columns(12)

- WALNUT CELL

Number of parts 6 Number of collection station 3 Number of checks 48

Gauges - Comparison Micrometer (2)
Height gauge(1)
Electronic Columns(5)

- LASER BASE

Number of parts 2 Number of collection stations 1 Number of checks 20

Gauges - Vernier(1)
Height gauge(1)
Electronic Columns(8)

- GIRTH RING

Number of parts 9 Number of collection stations 1 Number of checks 31

Gauges - Vernier (1)
Blade Micrometer(1)
Height gauge(1)
Bore gauge(2)
Micrometer(3)

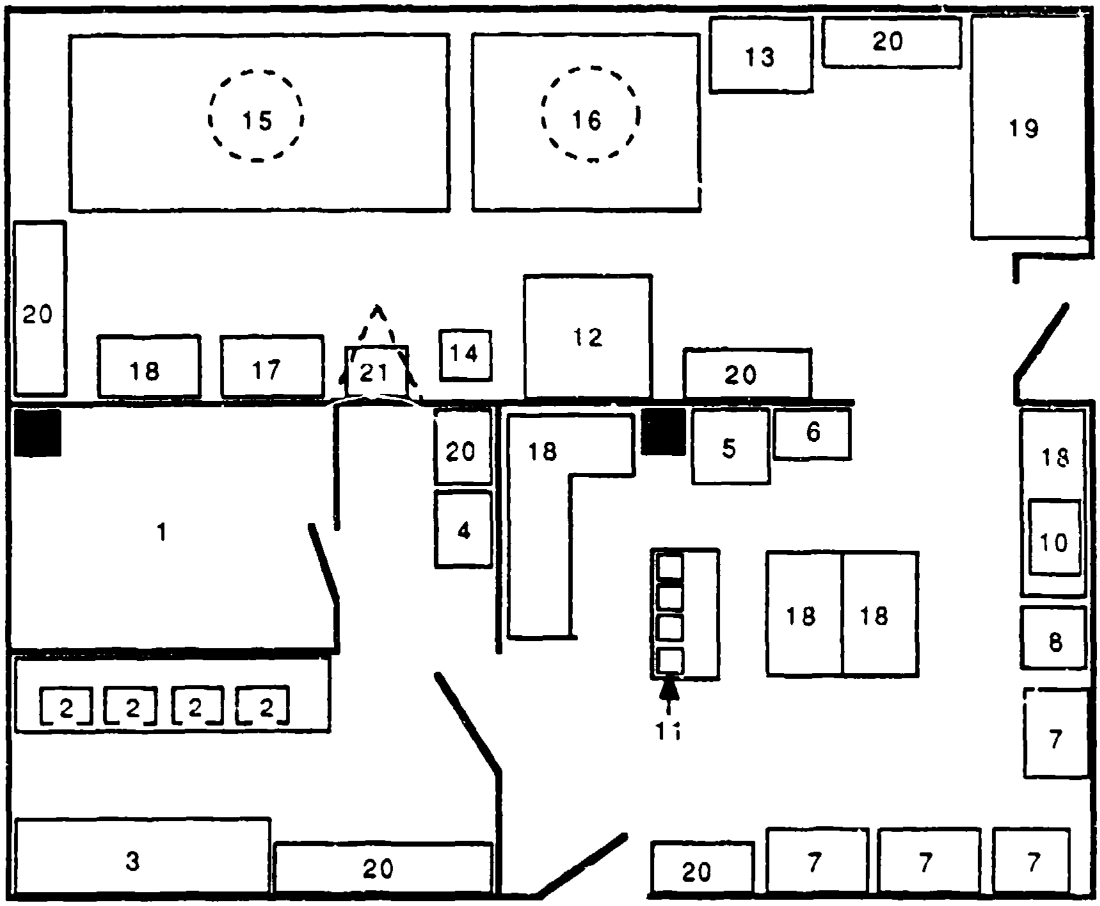
- 1 1/2" BAR CELL

Number of parts 39 Number of collection stations 1 Number of checks 239
Gauges - Micrometers(5)
Blade Micrometers(3)
Bore gauges(39)
Indicators(5)
Height gauge(4)
Electronic Columns(6)
Vernier(1)

- PALLET CELL

Number of parts 24 Number of collection stations 2 Number of checks 211
Gauges - Optical Measurement Machine(2) Number of holding fixtures 44

LAMINATION CELL



1. Soda Blast vacuum
2. SS White Soda Blast Units
3. Sink & Drain
4. Dry Ice Freezer
5. Dryer Oven
6. Bottled Gas
7. Ovens
8. Vented Hoods For Solvents
10. Burr Brushing Machine
11. Hot Presses
12. Lapping Machine
13. Ultra-sonic Cleaner
14. Center Lap
15. Internal Grinder (Bryant)
16. External Grinder (Tschudin)
17. Lapping Machine
18. Bench
19. Inspection
20. Shelving
21. Terminal

CNC Equipment

DNC Terminal

Figure 8.1 Lamination Cell Floor Layout

WALNUT & GIRTH RING CELLS

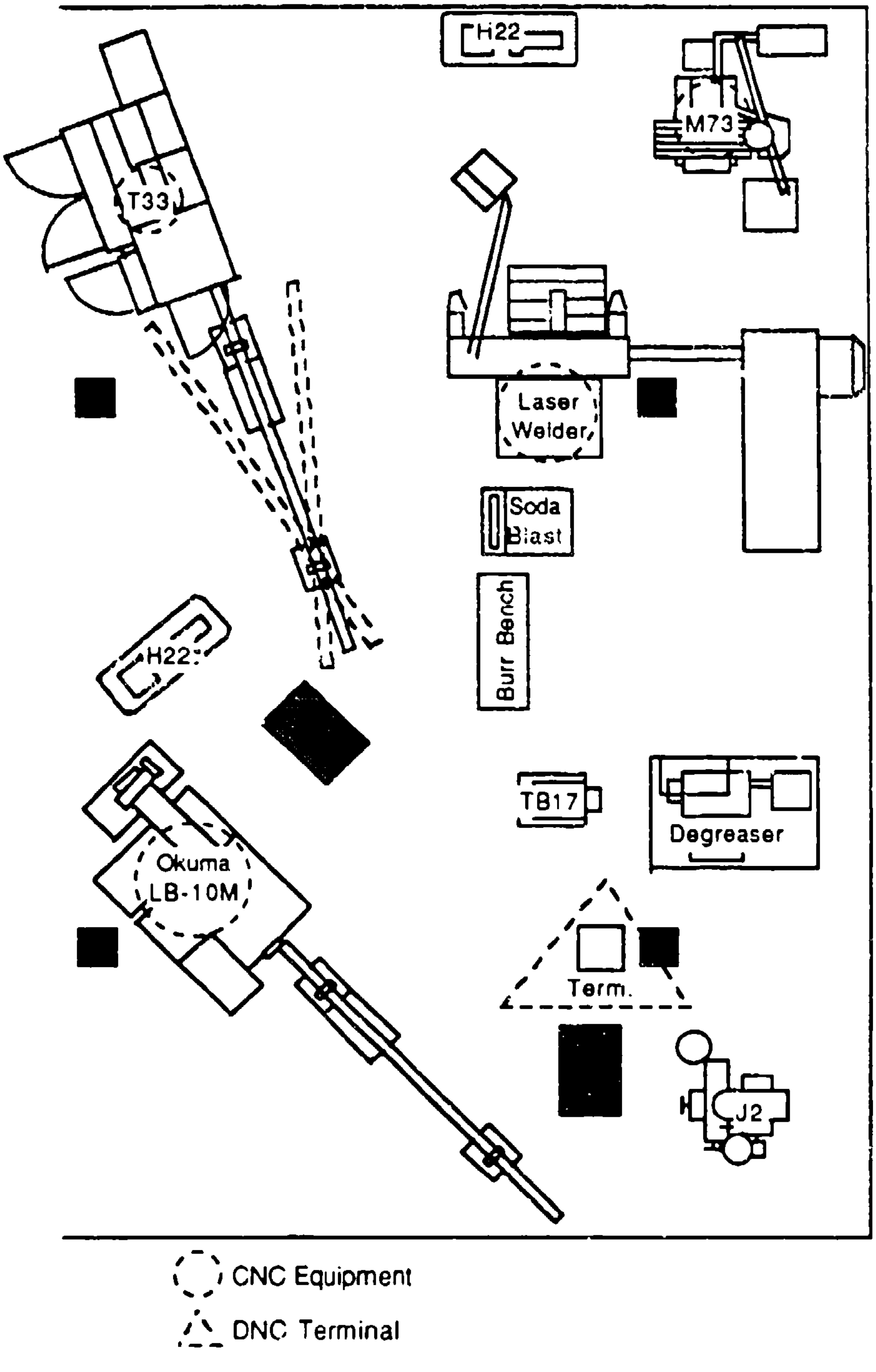
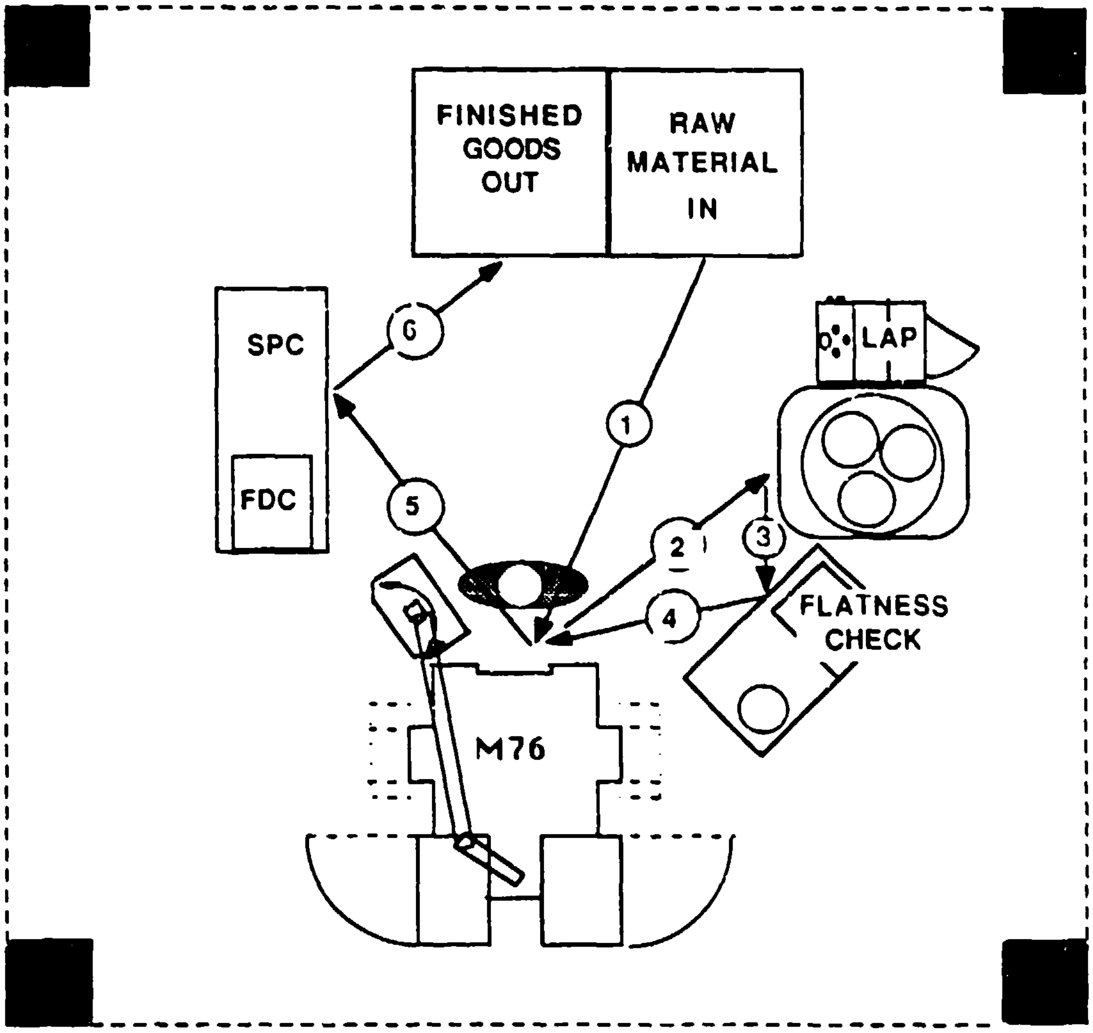


Figure 8.2 Walnut and Girth Ring Cell Floor Layout

LASER BASE CELL LAYOUT



MATERIAL FLOW

1. MILL, DRILL, & TAP BOTTOM
2. LAP BOTTOM 5PL
3. CHECK BOTTOM FOR FLATNESS
4. MILL DRILL & TAP COMPLETE
5. GAGE
6. FINISHED GOODS OUT

Figure 8.3 Laser Base Cell Floor Layout

PALLET CELL

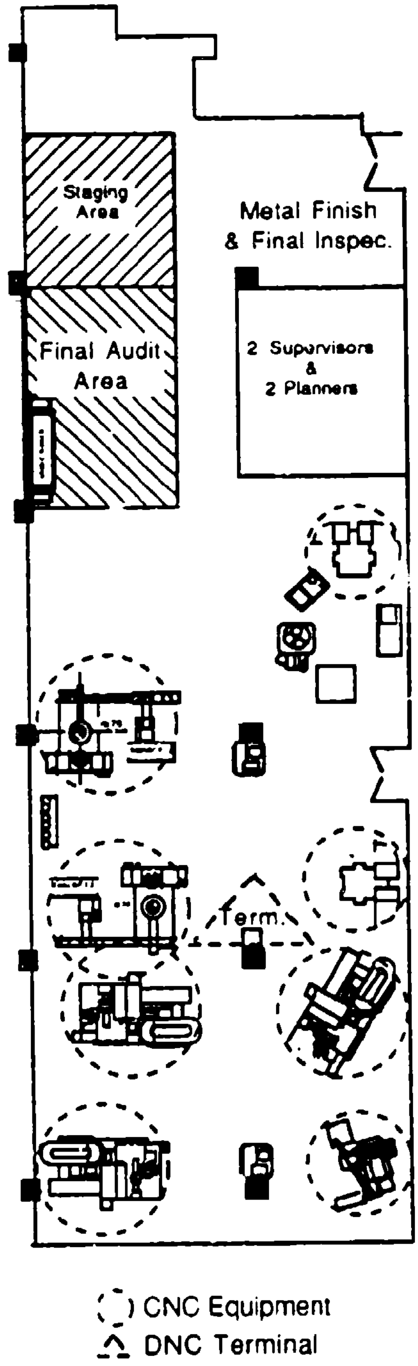


Figure 8.4 Pallet Cell Floor Layout

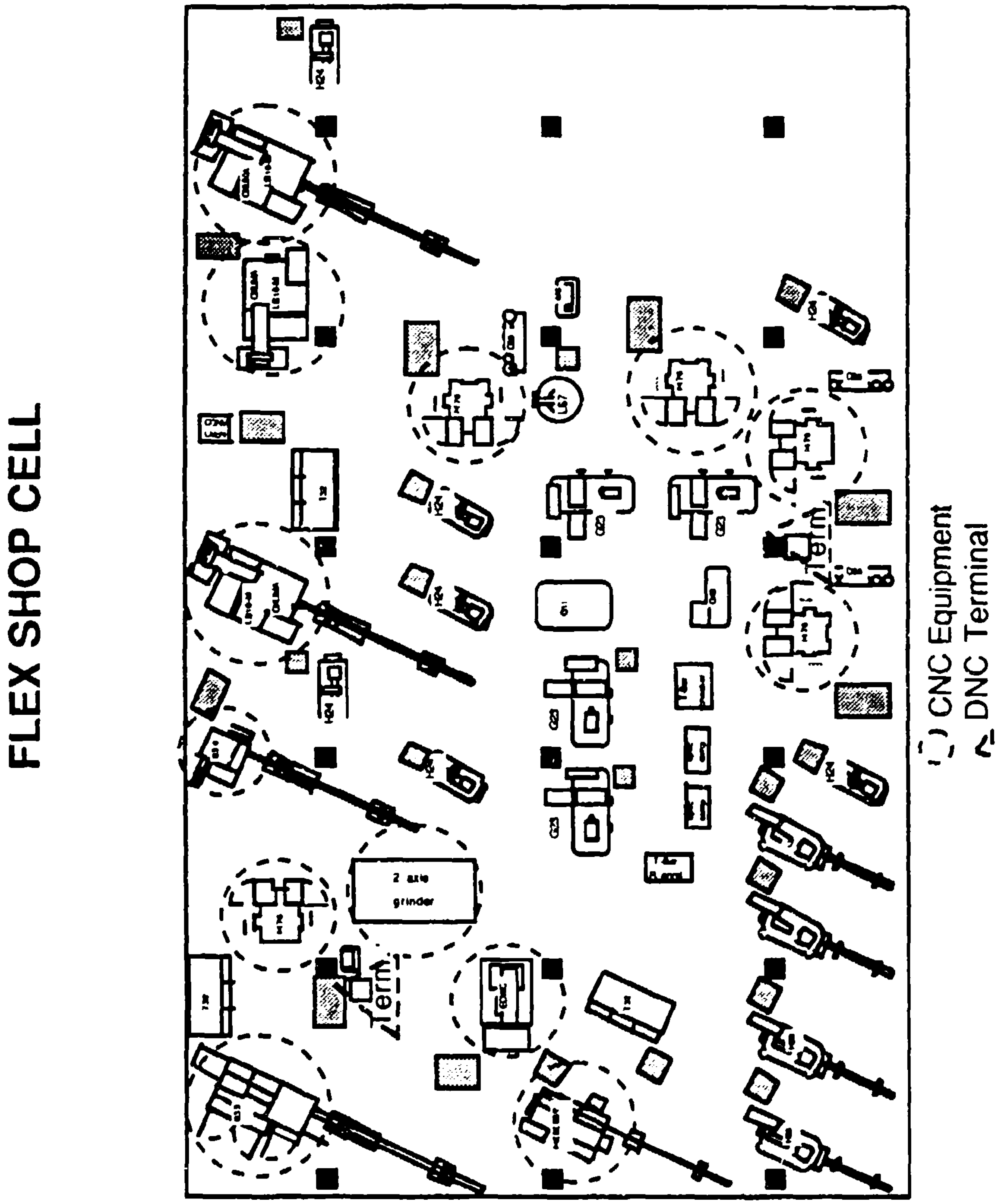


Figure 8.5 Flex Shop Floor Layout

SECTION 9

SYSTEM/EQUIPMENT/MACHINING SPECIFICATIONS

Each of the Work Cells is listed below showing their individual requirements. This is a result of the parts analysis for each of the parts to be produced by each of the cells. The work cells listed below are not in any list of importance or schedule.

1. Walnut Cell

   - Data Collector - Must be able to produce X(bar) & R charts and Histograms on dimensional data collected through various electronic gauges. Also must have the ability to produce attribute charts.

   - Gauges - Height gauge with readout of 0.0001"
     Comparison Micrometer with readout of 0.0001"
     Electronic Columns of readout to 0.00001"

2. Pallet Cell

   - Automatic Measurement Machine - Resolution X, Y, Z, of 0.0001" overall accuracy of ±0.0002" with travel rate of 1.0' per second. Programmable with ability to store programs.

   - Data Collector - Must be able to produce X(bar) & R charts and Histograms on dimensional data collected through various electronic gauges. Also must have the ability to produce attribute charts.

3. 1 1/2" Bar Cell

   - Data Collector - Must be able to produce X(bar) & R charts and Histograms on dimensional data collected through various electronic gauges. Also must have the ability to produce attribute charts.

   - Gauges - Micrometer with readout to 0.0001"
     Blade Micrometer with readout of 0.0001"
     Bore gauges with readout to 0.00005"
     Indicators with readout to 0.00005"
     Height gauge with readout to 0.0001"
     Electronic Columns with readout to 0.000020"
     Vernier with readout to 0.0005"

4. Lamination Cell

- Data Collector - Must be able to produce X(bar) & R charts and Histograms on dimensional data collected through various electronic gauges. Also must have the ability to produce attribute charts.

- Gauges - Height gauge with readout to 0.0001"
  Bore gauges with readout to 0.00005"
  Depth Micrometer with readout to 0.0001"
  Electronic Columns with readout to 0.000020"

5. Laser Base Cell

- Data Collector - Must be able to produce X(bar) & R charts and Histograms on dimensional data collected through various electronic gauges. Also must have the ability to produce attribute charts.

- Gauges - Vernier with readout to 0.0005"
  Height gauge with readout to 0.0001"
  Electronic Columns with readout to 0.000020"

6. Girth Ring

- Data Collector - Must be able to produce X(bar) & R charts and Histograms on dimensional data collected through various electronic gauges. Also must have the ability to produce attribute charts.

- Gauges - Vernier with readout to 0.0005"
  Blade Micrometer with readout to 0.0001"
  Height gauge with readout to 0.0001"
  Bore gauge with readout to 0.000050"
  Micrometer with readout to 0.0001"

SECTION 10

TOOLING SPECIFICATIONS

INTRODUCTION

Since this project does not have tooling per se, consideration was given to bore adaptors, fixtures, and special probe holders. These considerations were given to each cell by part number as warranted by the design of the part. Not all parts require special devices to check the part. See Figure 10.1 for examples.

BORE ADAPTORS

For controlling the size of a hole, it is necessary to have a large range of bore gauges. These have to be precision ground and capable of checking the entire tolerance range. The 1 1/2" Bar Cell has 39 such gauges. These bore adaptors fit onto the shaft of an electronic dial indicator which is used to transmit the readings to the data collector.

FIXTURES

The fixtures needed to support the Pallet Cell and others will all be of new design and require Quality Engineers working with Tool Design to pass on the fixture requirements. This process will involve a newly created fixture print which will be reviewed by Quality.

SPECIAL PROBE HOLDERS

In some cases, probe holders are required to hold the electronic probe in order to assure proper alignment and relationships. These holders are required to go through the same design function as in the previously described fixture design and build.

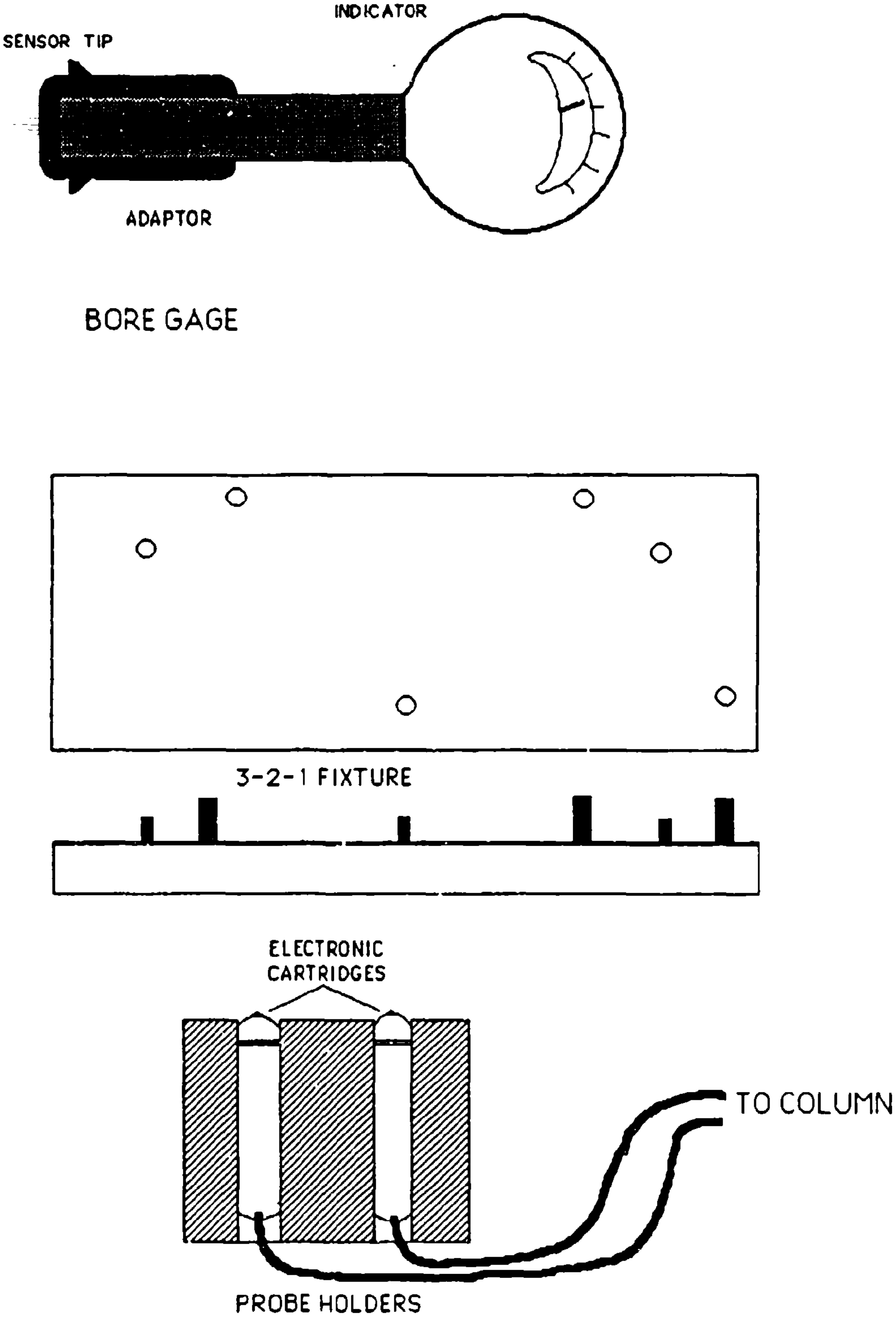


Figure 10.1 Bore Adaptors, Fixtures and Special Probe Holders

SECTION 11

VENDOR/INDUSTRY ANALYSIS/FINDINGS

STATISTICAL PROCESS CONTROL EQUIPMENT

A search was made of the manufactures of statistical process control (SPC) equipment with special care given to the following criteria:

- Accepts a wide variety of gauges.
- Easily displays charts to operator at any time.
- Will handle either variable or attribute data.
- Permits off line analysis of data.
- Allows data transfer to mainframes through a personnel computer.
- Operational in a factory environment.

Suppliers of data processing equipment were visited or requested to send in information on their systems. After reviewing the different systems, two suppliers became the fore runners. They were selected based on the above criteria plus considerations for servicing and training. The two suppliers are listed below:

- Verax Corporation
  Fairport, New York
- DataMyte Corporation
  Minnetonka, Minnesota

Other suppliers of this equipment which were considered but did not meet all of the criteria were Quality Measurement Systems of Macedon, New York, and Fowler Company of Newton, Maryland.

AUTOMATIC MEASUREMENT MACHINE

Consideration was given to two types of automatic measurement machines. One which uses a probe that touches the part to make measurements and the other system uses optics with a TV camera to measure the part. Both systems were observed during demonstrations. The selection was made based on the following criteria:

- Easily programmed.
- Could measure at least 95% of the parts to be machined.
- Accuracy to positional tolerance of 0.001".
- Ease of use by production operators or inspectors.
- Ability to store data for Statistical Analysis.
- Programs could be stored through a floppy disk system.
- Reasonable travel time

Those who were under consideration were Sheffield Corporation, Numerex Corporation and Optical Gauging Products. Optical Gauging was chosen because of their non-contact feature and the unit is easily programed.

HAND GAUGES

A variety of electronic digital gauges were selected primary on the application by which they would be employed. Several manufactures are being used. All the gauges are compatible with either of the data collecting equipment described earlier. A list of the manufactures follows:

- Bendix Corporation (Electronic Columns)
- Fowler Tool Corporation (Micrometers)
- Mitutoyo (Vernier)
- Starrett Company (Micrometers)
- Dorsey Gauge Company (Comparator Micrometers)
- Federal Gauge Corporation (Indicators)
- Ono Sokki (Height gauge)
- Mahr Gauge Company (Indicators)

SECTION 12

EQUIPMENT/MACHINERY ALTERNATIVES

AUTOMATIC MEASUREMENT MACHINE

There are several manufactures of this type of equipment that can perform to the specification. This technology has existed for over 10 years. As an alternative to the non-contact approach, programmable machines with movable probes which touch the part for dimensional checking are available from Sheffield, Numerex, Mitutoyo, and Federal amongst others.

DATA COLLECTORS

Systems are available which are used with gauges to provide SPC graphs. Fowler, Mitutoyo, Brown and Sharp just to name a few, all provide a SPC System to be used with their gauges. Although some of these systems require a dedicated personnel computer, they could be link together if the distance is not over a couple hundred feet to permit communications.

GAUGES

Gauges which are usable with data collectors are plentiful and are manufactured by every major gauge manufacture. There is no problem substituting one manufactured gauge for another.

SECTION 13

MIS REQUIREMENTS/IMPROVEMENTS

The SPC equipment will interface with Honeywell Manufacturing System (HMS), Process Management System (PMS), and Factory Data Collection (FDC) without modifications to other systems hardware or software. As of this writing, a Quality System was being investigated and piloted by the Fabrication Facility in conjunction with Honeywell's Aerospace and Defense Quality Council. The pilot has not been completed. Special enhancements as far as ITM Project 43 is concerned, such as automatic uploading of data, is being considered as part of the software initial specifications.

The SPC system as outlined in the previous Sections does permit the uploading of data manually by the inspector or by an engineering aid.

COMPUTER APPLICATION

Fab Fac Quality pioneered Factory Data Collection in 1982 for the Honeywell ISM group. Microcomputers were installed in the Inspection area of the Glass Fabrication Facility to gather production yield data and to store critical measurement data needed for assembly. Programming and training was handled by Quality. These units are being used today. Data is transferred weekly to Honeywell mainframe computers by an engineering student aide.

Since 1982, three personal computers have been acquired and are used by supervision and the engineers. They are used to generate reports, modify programs for floor data collection, statistical analysis, and record keeping.

Honeywell MAvD recognized the importance of computer-integrated manufacturing systems prior to the start of Honeywell's Tech Mod program. Consequently, there are several ongoing MIS projects. Each provides an essential CIM building block. Existing systems projects include:

- 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 paperless Production Engineering tool designed to allow on-line entry and modification of parts lists, detail summaries, layouts, and process detail.

- Factory Data Collection (FDC)

A custom-made system designed to automate factory data collection through the use of data entry terminals, bar code readers, and voice data entry systems. 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. Includes plans to integrate and automate the design-to-production transition and provides for direct links to DNC equipment.

The above mentioned systems will have little effect on ITM Project 43 with the exception of Factory Data Collection. The future plans are to use FDC to collect and store all quality data. The retention of the data for history will be handled on a batch mode and will be stored nightly. The inspectors will interact with FDC for reporting their time, audit reports and any discrepant material.

SECTION 14

COST BENEFIT ANALYSIS/PROCEDURE

OVERVIEW

The final analysis of Project 43 was based on six independent fabrication cells or work areas. These areas were:

1. Walnut Cell

2. 1.5 Inch Bar Cell (part of the Flex Cell)

3. Laser Cell

4. Girth Ring Cell

5. Pallet Cell

6. Lamination Cell

Individual analysis' have been generated for each of the cells and work areas. This breakdown simplified the savings analysis due to multiple implementation start dates and various methods of deriving savings.

Actual standard hours was identified and used to calculate savings for this project. This driver was analyzed on a cell by cell basis and identified using the methodology shown in the process diagram of Figure 14.1.

MANUFACTURING SCHEDULES

This cost driver and its associated savings was based on manufacturing schedules. Due to complexity and accessibility, the following three methods were used to derive the ten year projections for each cell or work area:

1. Marketing plan volume projections by product device.

2. Current year volumes (piece part or hours) escalated by each related operation's revenue plan projections.

3. Current year volumes (piece part or hours) with no projected change.

PROJECT 43
COST BENEFIT ANALYSIS METHODOLOGY

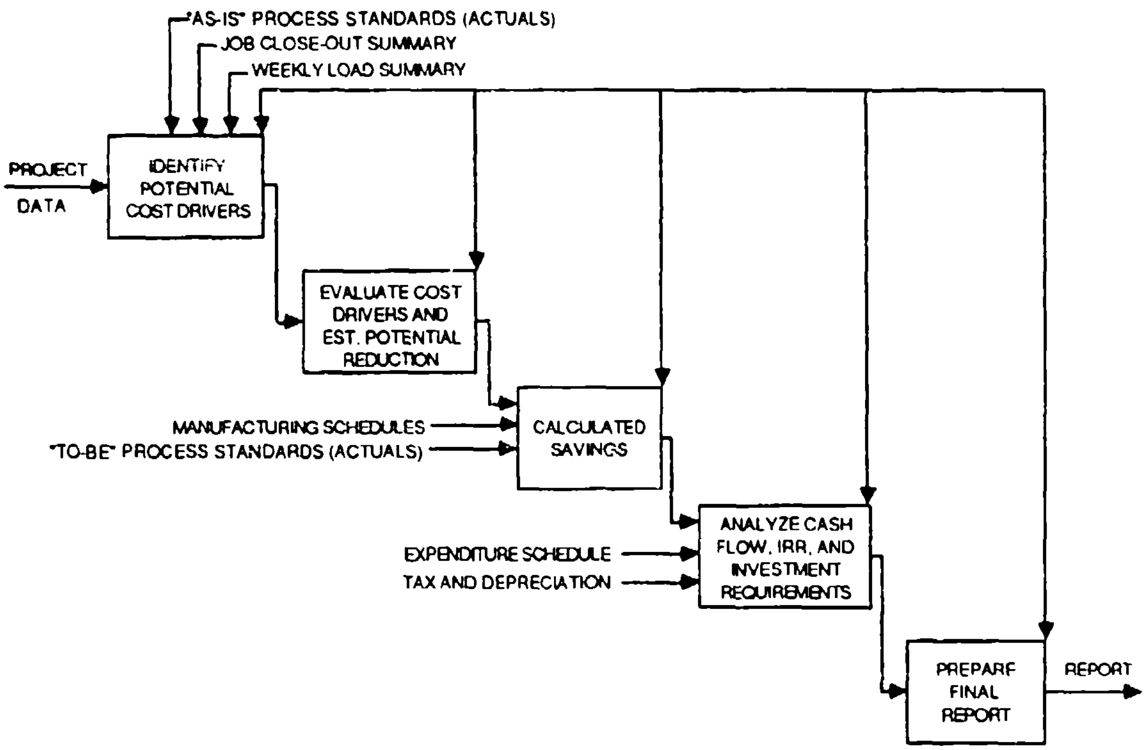


Figure 14.1 Project 43 Cost Benefit Analysis Methodology

After establishing projected volumes for each cell, an attrition rate was calculated and added to each cell's volume. These rates were based on past history by part number and received from Fab Fac's Production Control Department. Not all part numbers in the analysis received an attrition rate due to the maturity of the part and/or availability of data.

ACTUAL STANDARD HOUR SAVINGS

The "As-Is" baseline for the dedicated work cells was taken form an internal Honeywell "Job Summary Report". This report listed the historical actual hours generated by part number and job order number.

The project team collected job orders from a range of years, late 1983 through 1985, to acquire a reliable sample size.

After gathering these hours, a computer program was developed to compile and establish average actual production hours per piece (reference Figure 14.2). These average hours per piece were used for the "As-Is" baseline in calculating individual part number savings.

The "To-Be" standard hours for the dedicated cells were either established by Industrial Engineering or Honeywell Quality Engineers (Q.E.'s). The time standards originally estimated by Q.E.'s were reviewed and edited by the Industrial Engineering staff.

CAPITAL AND EXPENSE

The capital, recurring and non-recurring expense for Project 43 are shown in Figure 14.3.

PROJECT SAVINGS AND CASH FLOWS

The savings to be realized by this project exceed Honeywell's Military Avionics Division hurdle rate. The Projects' cash flows are shown in Figure 14.4 with the assumption that capital is available per the implementation plan.

PART	END	CELL	JOB	DATE		QTY		4004			4005			4006			4007			6154			TOTAL MINUS DEPT 6154		
NUMBER	ITEM	NO.	NO.	START	FINISH	SRT	FIN	SU	RUN	RWK	SU	RUN	RWK	SU	RUN	RWK	SU	RUN	RWK	SU	RUN	RWK	SU	RUN	RWK
			6475	081083	041784	745	724	6.5	87.0	1.5	1.0	159.0		14.5	227.4			16.5		20.1	14.6	2.0	22	489.9	1.5
			6476	081083	062184	478	426	3.9	51.9		1.0	99.2		3.0	128.4	2.0		10.1		7.8	17.7		7.9	289.6	2
			6477	081083	070284	500	483	1.8	55.7		.5	107.9		8.8	228.5			11.5		15.8	12.5		10.3	403.6	
			6289	042583	020284	472	517	4.3	54.2	11.5	3.0	84.0	1.5	4.5	161.0	3.0		11.9	6.8	21.2	19.0	1.3	11.6	311.1	22.8
			A555	051584	062584	47	35			2.0			1.1						1.3			1.0			4.4
TOTAL HOURS						2242	2185	15.7	240.8	15	5.5	450.1	2.6	30.8	745.3	5		50	8.1	64.9	63.8	4.3	52	1494.2	30.7
AVERAGE HOURS/PIECE								.0072	.11387	.0069	.0025	.20600	.0012	.0141	.34110	.0023	0	.02288	.0037				.0238	.68384	.0141

"AS-IS" AVERAGE LEAD TIME (DAYS) = 244

"AS-IS" AVERAGE ACTUAL MFG HRS/PIECE = .72174

"AS-IS" TOTAL INSPECTION HOURS = 133

"AS-IS" TOTAL INSPECTION HOURS/JOB = 26.6 AVERAGE LOT SIZE = 437

Figure 14.2 Average Actual Production/Inspection Hours/Piece (Example)

PROJECT 43 TOTAL EXPENDITURE SCHEDULE

	Cost	Capitalization Date
CAPITAL COSTS		
MACHINERY COSTS		
** DATAMYTE SPC (2)	$6,029	1986
** Q-SEE (CMM) (2)	$227,758	1988
** VERAX SPC (5)	$24,116	1988
** VERAX SPC (4)	$19,292	1989
** VERAX SPC (1)	$4,823	1990
	$6,029	1986
	$251,873	1988
	$19,292	1989
	$4,823	1990

TOTAL MACHINERY COSTS	$282,017	
TOOLING COSTS		
** FIXTURES (IN-HOUSE)	$150,593	1988
** GAUGES	$9,813	1988
** FIXTURES (IN-HOUSE)	$24,955	1989
** GAUGES	$27,477	1989
** GAUGES	$2,756	1990
	$160,406	1988
	$52,432	1989
	$2,756	1990

TOTAL TOOLING COSTS	$215,595	
	$6,029	1986
	$412,279	1988
	$71,725	1989
	$7,579	1990

TOTAL CAPITAL COSTS	$497,612	

	Cost	Year Expended
EXPENSE COSTS		
NON-RECURRING EXPENSES		
** GAUGES	$4,206	1988
** TRAINING (HI)	$9,315	1988
** GAUGES	$11,776	1989
** TRAINING (HI)	$6,210	1989
** GAUGES	$1,181	1990
** TRAINING (HI)	$3,105	1990
	$13,521	1988
	$17,986	1989
	$4,286	1990

TOTAL NON-RECURRING COSTS	$35,793	
TOTAL CAPITAL + NON-RECURRING	$533,405	1990
RECURRING EXPENSES		
ANNUAL MAINTENANCE (CMM MACHINES)	$3,850	1988
UPGRADE DATA COLLECTORS	$385	1988
UPGRADE DATA COLLECTORS	$330	1989

TOTAL RECURRING	$4,565	

** Costs contain a 15% contingency

Figure 14.3 Project 43 Expenditure Schedule

HONEYWELL PROPRIETARY

SEE CBA FINAL REPORT FIGURE 5.4

Figure 14.4 Project 43 Cash Flows

SECTION 15

IMPLEMENTATION PLAN

OVERVIEW STRATEGY

The timing of ITM Project 43 will follow the implementation of ITM Project 44. The installation of this project will occur as each work cell of ITM Project 44 is completed (see Figure 15.1). (There are instances where the delivery lead time for Project 43 equipment exceeds the lead time for Project 44 equipment necessitating the ordering of the Quality Assurance equipment prior to that for Project 44.) The SPC training, which involves both the production and inspection personnel, will occur as each cell is brought up to speed and will be the responsibility of the Quality Engineering Department.

IMPLEMENTATION OF CELLS

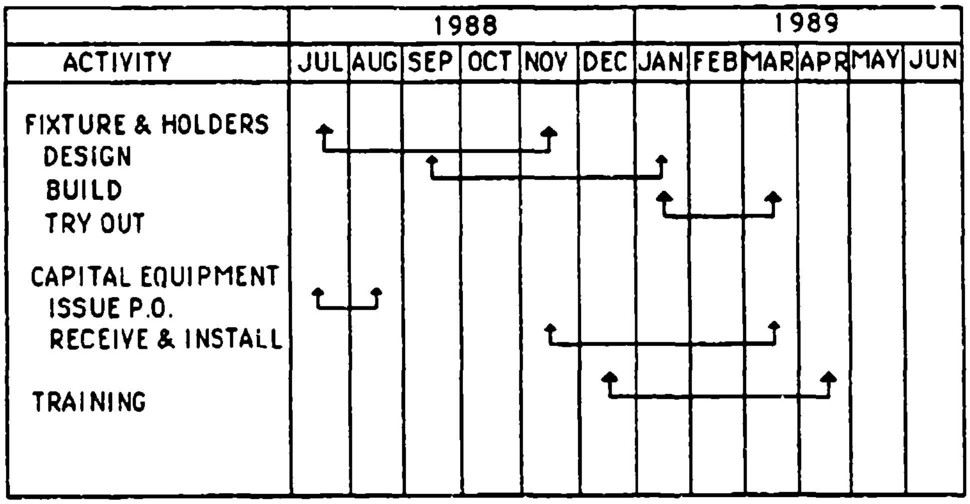
The schedule dates for implementation of each of the work cell is outlined below:

- Laser Base Cell — March 1986 through January 1987
- Pallet Cell — July 1988 through April 1989
- Walnut Cell — March 1988 through October 1988
- Lamination Cell — March 1989 through December 1989
- Girth Ring Cell — July 1988 through April 1989
- 1 1/2" Bar Cell — March 1989 through December 1989 (Part of Flex Shop)

The Laser Base Cell has been running since January of 1987. The data collectors are providing statistical graphic displays for both the operators and the inspectors.

An individual from the Quality Assurance Department will be selected to follow up on the installation of each work cell. That person will be responsible for ordering the equipment, having fixtures designed and built as needed, procuring the gauges, coordinating the training and start up of the quality function of the cell.

PALLET CELL



LASER BASE CELL

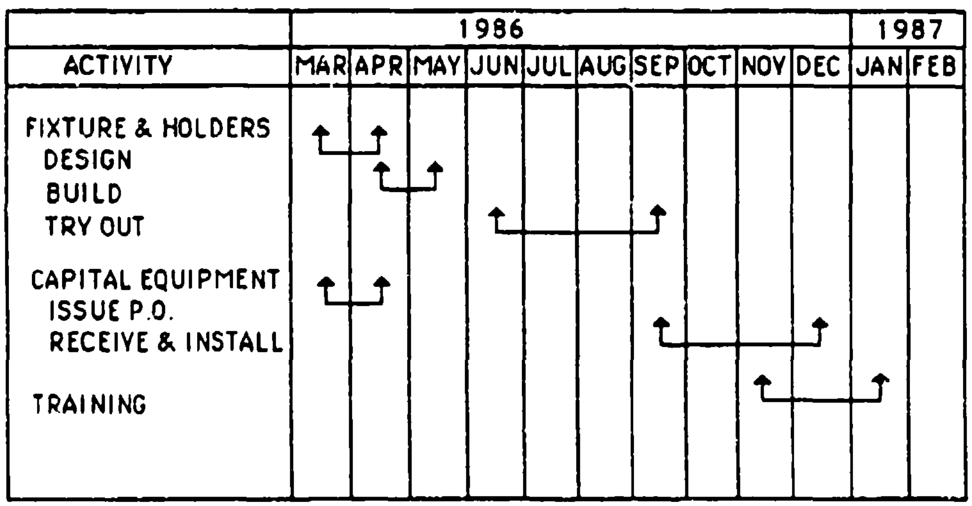
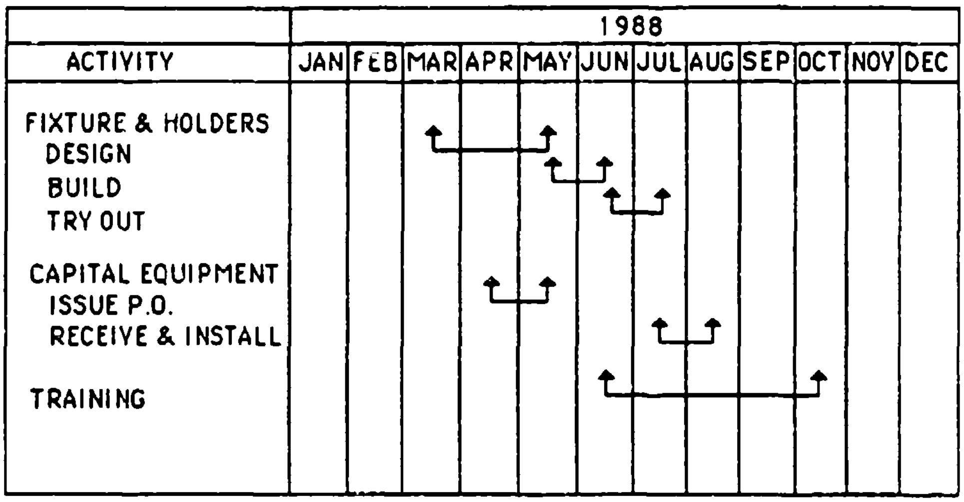


Figure 15.1 Project 43 Work Cell Implementation Schedules

WALNUT CELL



LAMINATION CELL

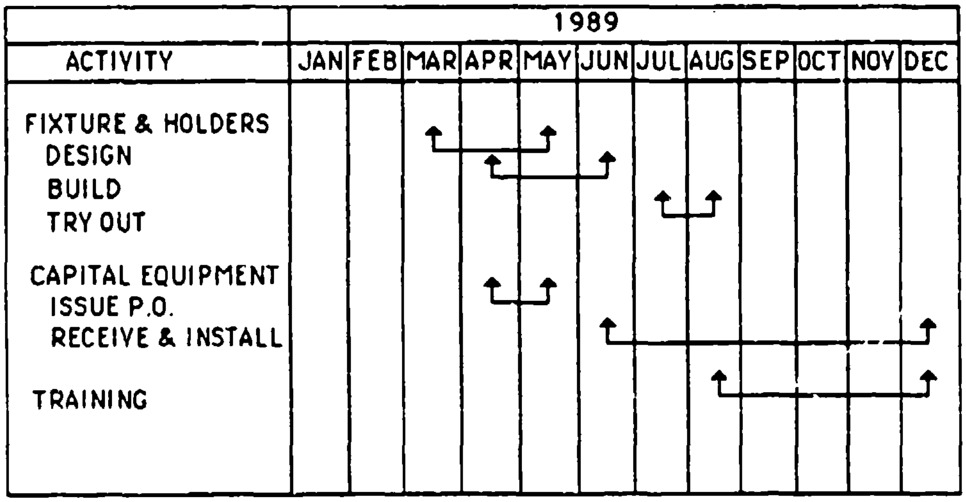
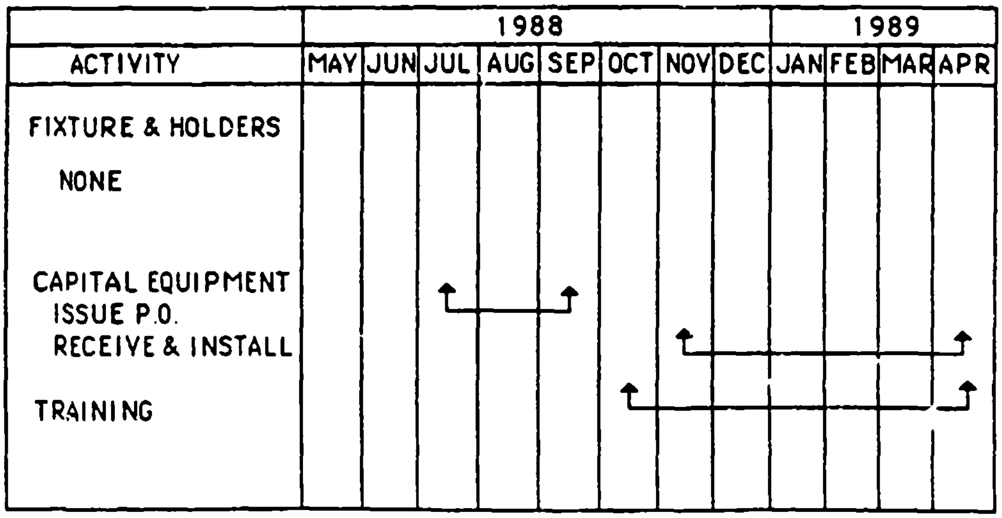


Figure 15.1 Project 43 Work Cell Implementation Schedules (continued)

GIRTH RING CELL



1 1/2" BAR

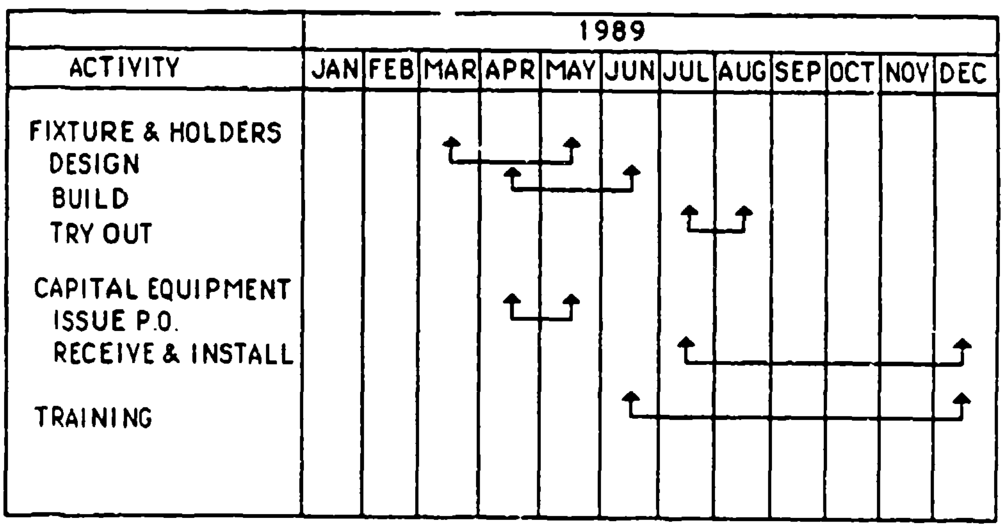


Figure 15.1 Project 43 Work Cell Implementation Schedules (continued)

SECTION 16

PROBLEMS ENCOUNTERED AND HOW RESOLVED

DATA RETENTION

MIL-Q-9858 requires the retention of data showing disposition including the nature and number of observation made and the number and type of deficiencies found of hardware obtained during the manufacturing process. The use of data collectors does not meet this requirement. The amount of data which can be stored by these systems will not meet contractual requirements of seven years.

RESOLUTION

Honeywell Factory Data Collect (FDC) will, in Phase 3, allow for the retention of this data resulting in the elimination of the present day system of hard copy record cards. This is scheduled for the third quarter of 1988.

SECTION 17

AREAS FOR FUTURE CONCERNS/DEVELOPMENT

FUTURE CONCERNS

The conformance to Mil-Q-9858, with respect to objective evidence of quality and record retension, was an initial concern. The conformance to contractual requirements of proof of acceptance requires the ability to present evidence to DCAS as to the inspection performed. The ability to retrieve data and reproduce charts meets these requirement. DCAS is aware of the project and its impact on changing the way Honeywell approaches the requirements of Mil-Q-9858. Presentation have been made to the local DCAS office outlining the plans of ITM Project 43.

FUTURE DEVELOPMENTS

There is opportunity to expand the concept from just work cells to all of the Fabrication Facility. This would include the Model Shop and Flex Shop. With the advancement of computer aided design, it is reasonable to expect a translator for the computer data base to automatically produce an inspection program for the coordinate measurement machines thus permitting SPC control of small run jobs.

Another opportunity lies with our subcontract suppliers. The use of SPC in their shop could result in them electronically transmitting data to Honeywell for acceptance prior to shipment. The passed hardware could then be shipped directly to the using area. A system of electronic record retention could be developed.