DESIGN AND IMPLEMENTATION OF A WINDOWS NT NETWORK TO SUPPORT CNC ACTIVITIES

Final Report

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Abstract

The Manufacturing, Materials, & Processes Technology Division is undergoing dramatic changes to bring it's manufacturing practices current with today's technological revolution. The Division is developing computer automated design and computer automated manufacturing (CAD/CAM) abilities. The development of resource tracking is underway in the form of an accounting software package called Infisy. These two efforts will bring the division into the 1980's in relationship to manufacturing processes. Computer integrated manufacturing (CIM) is the final phase of change to be implemented. This document is a qualitative study and application of a CIM application capable of finishing the changes necessary to bring the manufacturing practices into the 1990's. The documentation provided in this qualitative research effort includes discovery of the current status of manufacturing in the Manufacturing, Materials, & Processes Technology Division including the software, hardware, network and mode of operation. The proposed direction of research included a network design, computers to be used, software to be used, machine to computer connections, estimate a timeline for implementation, and a cost estimate. Recommendation for the division's improvement include action to be taken, software to utilize and computer configurations.

Introduction

The Manufacturing, Materials, & Processes Technology Division is undergoing dramatic changes to bring it's manufacturing practices current with today's technological revolution. The Division is developing computer automated design and computer automated manufacturing (CAD/CAM) abilities. The development of resource tracking is underway in the form of an accounting software package called Infisy. These two efforts will bring the division into the 1980's in relationship to manufacturing processes. Computer integrated manufacturing (CIM) is the final phase of change to be implemented. This document is a qualitative study and application of a CIM application capable of finishing the changes necessary to bring the manufacturing practices into the 1990's.

Current status of Manufacturing in EM at JSC

Software:

The current major software packages used by EM include Infisy, Pro/Engineer, Unigraphics, and AutoCAD13. Infisy is being implemented to collect manufacturing and administrative data for accountability. Pro/Engineer is being used for CAD drawings and design analysis. Unigraphics is being used to convert drawings into NC programs. AutoCAD13 was used to convert drawings that have come into the division from AutoCAD users. There is no software being used to integrate the operation of the manufacturing operation.

Hardware:

The hardware can be divided into the two categories of machines on the production floor and the computers available to service the machines. All but one of the numerically controlled machines are network ready and can be linked to the network with minimal effort. The older Mazak machining center will need an adapter to allow the delivery of NC files. This can be accomplished with and after market adapter. Other than the NT server there are no computers on the production floor to start building a computer integrated manufacturing system (CIM).

Network:

The network in building ten is incomplete for CIM use. It is being used to support a few computers that are used primarily for computer automated manufacturing (CAM) and administrative needs. The existing network has been planned to be expanded to better serve the building. Once the expansion is complete there will have to be an additional expansion to support a fully integrated manufacturing operation.

The extent of use of the existing network cabling between buildings nine and ten and within building ten is as follows. A four strand fiber cable exists between the two buildings with only two strands being used. At this time this part of the net may be adequate but it may be necessary to use the other two fibers to isolate the graphics terminals and their heavy traffic from the general network traffic. It is estimated that under non-graphic communications modes the network is functioning at about 10% capacity but when the graphics stations are transmitting this usage increases to 50%. This is not a problem with the current status of the two buildings but if CIM is implemented then network use will have to be reevaluated. Within building ten the network use consists of the graphic stations (4) and a few management stations (3). The initial expansion of the network will connect electronics on the second level and a few other work stations to the NT servers.

Mode of operation:

The present mode of manufacturing operation can be dated back to the 1970's. Brining the CAD/CAM and Infisy applications on line will bring the manufacturing facilities up to the 1980's. This mode of operation still is not what is required of manufacturing operations that are going to compete in the late 1990's and into the years beyond. To become a competitive operation EM must show accountability for all of its inputs, processes, and outputs.

Proposed Action

Network design:

A plan for the expanded network in building ten will be proposed to serve as a file transfer system for implementing CIM. This plan will include the wiring consisting of fiber-optics, thinnet wire and twisted pair. Hardware included in the plan will include bridges, hubs, and the server.

Computers:

Existing micro-computers will be configured and tested to bring a basic CIM operation into a functioning state. The computers will be tested at varying stages of computing power. The varying powers will include the speed of the computer, size of the random access memory (RAM) and the size of the existing hard drive (HD). A minimum configuration that is acceptable for the CIM operation will be recorded so surplus computers can be recycled at NASA-JSC.

Software:

Commercially available software will be evaluated to determine if the software is suitable for the needs of EM implementing CIM. Once a software package has been identified it will be tested for compatibility with the machines, computers and the network. A recommendation for the software will be recorded.

Machine to computer connections:

Connections for common types of machines will be tested. This will ensure ease of instillation for the cabling between the computers and the machines.

Time Line:

A timeline will be developed taking into consideration the funding of a grant to continue this work for the 1995-96 academic year, without the grant being funded and a planned return for next summer as a visiting faculty member.

Cost Estimate:

A cost estimate for the software, software instillation, and training will be included. Not included in this estimate will be the cost of the extended network, computers for upgrading the CIM system, possible other needed software, and small items.

Network Design

There is a need to locate bridges and hubs for security and isolation of the network failure. If there is a failure of a workstation or a machine it could threaten the integrity of the network. The first step is to locate the primary domain controller (PDC) and the backup domain controller (BDC) behind bridges to isolate them from potential problems, provide security and additionally limit the excess data flow which can slow down network operations dramatically. Once the computers are isolated the building should be zoned into five zones so network or hardware problems can further be isolated. Additional fiber should be run between the domain controllers and the bridges to eliminate electrical interference and loss of digital signal within building ten. See figure 1 for machine zoning and placement of the bridges and hubs.

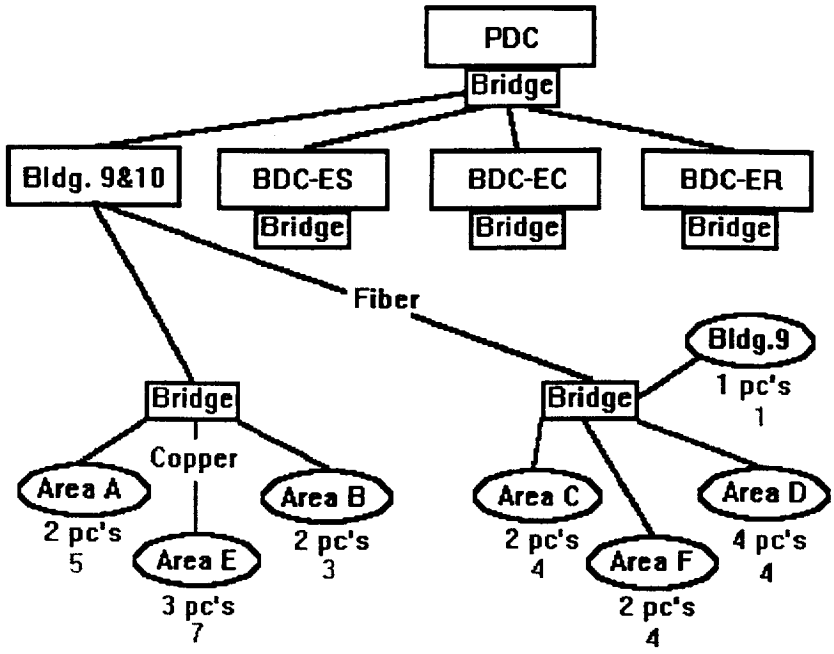


Figure 1

The large boxes represent the PDC and BDC's. The red boxes represent the proposed bridges for net isolation and security. The connecting net is represented by blue and green lines that represent fiber optics and twisted pairs of copper wire respectively. The ovals with letters in them represent the isolated areas or machine zones and/or hubs. The purple text are the numbers of computers needed on the floor and the light blue color text represents the number of machines in each zone.

Justification for zoning the machines is to limit the network damage in case of catastrophic failure that could happen in a machine, computer, or the net connecting the machine or the PC running the machine. To strategically place the bridges and hubs so they can economically facilitate the distribution of data it will be necessary to divide Building ten into six zones and one zone for building nine's model shop. The zones will create areas in which similar data and file size can be transferred. These zones are depicted in figure 2. Note that Building 9 is to the bottom of figure 2.

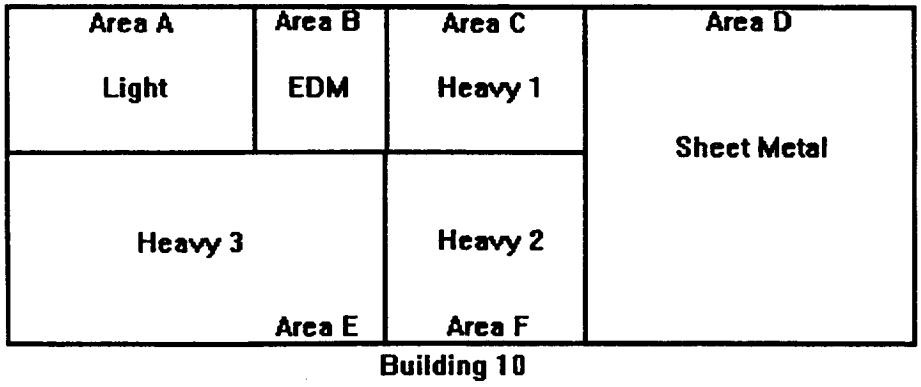


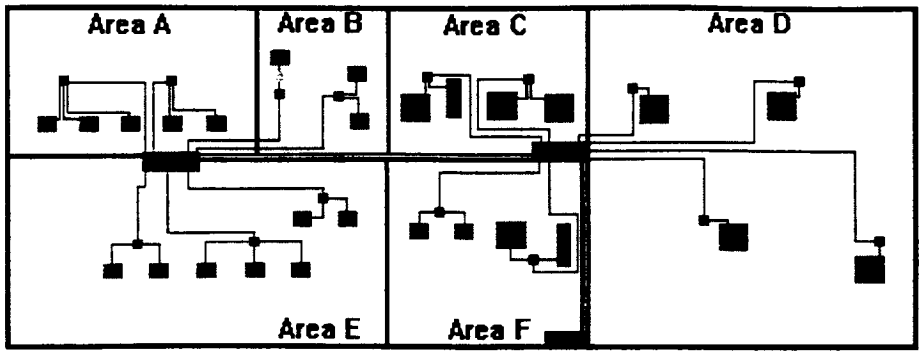
Figure 2

Area A includes vertical milling machines. Area B contains the EDM machines and one tape punch machine. Area C contains the Mazak SV-25, Mazak SlantTurn, and the two Hurco BMC 50's.

Area D contains all the "sheet" type equipment. Area E contains the Hurco's with tool changers. Area F contains the larger machining centers. Note that the PDC and BDC will be housed in area F room 135.

Feasibility and number of workstations on the production floor.

The reason for placing work stations on the facility floor is to perform two functions related to the inevitable transformation to CIM technology. The first function is to deliver NC programs to the supported machines. The second function of the stations will be to support production data collection and delivery of this data to the PDC. The final implementation of the NT work station is to limit the use of the PC's to manufacturing processes directly related to CIM only.



Building 10

The blue lines represent the locations of fiber for data transfer. The green lines are copper wire used to finish the connection. The red boxes represent the bridges used for isolation of the zones. The blue boxes represent the machines to be networked. The purple boxes represent the PC's.

Computers

Acquisition:

The acquisition of computers from surplus and redistribution (S&R) was done with great care. A bootable disk was built that would supply the DOS programs of f-disk, memory check, scandisk, and Microsoft diagnostics. This disk was built on a 3.5" disk but computers that booted to the 5.25" disk had to have the drives switched for testing. Monitors were acquired in excess of the number of computers. This was due to the loss of monitors during the burn in period of two days. Keyboard to be used by these computers must have the special function keys across the top of the keyboard. The keyboards with the special function keys along the left side will not function with the 386 computers. All disks involved with the configuration of these computers should be locked and the anti-virus program should be loaded second after DOS is loaded.

Configuration options:

The varying "powers" of computers will include the speed of the computer, size of the RAM and the size of the existing HD. A minimum configuration for CIMNET was reported so computers can be recycled at NASA-JSC. The computers available at this point pose several identifiable road blocks to implementing the basic components of a CIM operation. The computers available are 386sx's running at 6 to 20 MHz. This is not a problem for NC file transfer but is a problem for collecting, displaying and processing other data. The HD on these computers will limit the amount and type of software to be placed on the computers. Because of these limitations four models will be built and tested. Four models will use the 386's and one will be a 486 using NT as its platform. CIMNET software will be used because they support DOS only, Windows For Workgroups (WFW), and NT stations. Two versions of the software have been acquired for testing. One that supports the DOS application (DNCJunior) and one that supports WFW and NT (DNCplus).

Model 1: 1355807

A 386sx with a 20meg hard drive, 5 meg. RAM will be equipped with DOS and the CIMNET DNC junior software. This model is expected to save the most room on the small hard drives but **will not be user friendly**. Once the software is configured the setup will under go testing to determined usability. It will also be noted that this machine will not support a good link to the net and will not provide the feedback and accountability needed.

Model 2: CPU: 1242161 Monitor: 1009326

A 386sx with a 80meg hard drive, 4 meg. of RAM will be equipped with DOS, WFW, Anti-various and the CIM software. This model is expected to save the most room on the small hard drives. Once the software is configured the setup will be moved to B10 to under go testing on a group of different machine brands and types. It will also be noted that this machine will support net connectivity and the feedback needed for accountability.

Model 3: CPU: 1356026 Monitor: 1009323

A 386sx with a 40meg hard drive will be equipped with DOS, WFW, Anti-various and the CIM software. This model is expected be the model implemented until proper PC's can be purchased. Once the software is configured the setup will be moved to B10 where it will be tested on a group of different machine brands and types. It will also be noted that this machine will support net connectivity and the feedback needed for accountability.

Model 4: CPU: 1297775 Monitor: G042811

A 386sx with a 80meg hard drive, 4 meg. of RAM will be equipped with DOS, WFW, Anti-various and the CIM software. This model is expected be the model implemented until proper PC's can be purchased. Once the software is configured and the software stripped the setup will be moved to B10 where it will be tested on a group of different machine brands and types. This machine will support net connectivity and the feedback needed for accountability. The bar-code reader will be installed and tested for practicability.

Model 5: 1354925

A 486sx with a 212meg hard drive 8 meg. RAM will be equipped with NT and the CIM software. This model is expected be the model implemented when proper PC's can be purchased. Once the software is configured and the software user limits have been developed then setup will be moved to B10 where it will be tested on a group of different machine brands and types. This machine will support the ultimate net connectivity and the feedback needed for accountability. The bar-code reader will be installed and tested for practicability.

Computer Testing Results

The testing for model one was as expected. The computer could use the software but was not user friendly. Because of the non-user friendly aspects of the software further discovery was not warranted. The testing on models two through four was successful. It didn't matter what the speed or size of the hard drive was the CIM and network software functioned correctly. It was found that the amount of random access memory has to be over four meg. and preferably over five meg. to run the CIM software tested. The fifth model was not constructed and tested due to a lack of time. The following page contains the computers identification tags and how they are configured.

Computer Tracking

Shearrow	Identification Numbers			Computer Characteristics			Software Installed			Software Installed			Service Performed		
7/8/95	CPU	CRT	Key	Hard	RAM	Mhz	DOS	WFW	Anti.	Mouse	CIM	Psdwd	Scan	Defrag	Mem
Del 320	1242161	1009326	00103	20/	4	20	6.2	3.11	X	Win	X	EM3	X	X	X
Del 320	1356026	1009323	02674	40/	4	20	6.2	3.11	X	Win	X	EM3	X	X	+2meg
Del 310	1297775	G042811	02311	80/	4	12	6.2	3.11	X	Win	X	EM3	X	X	X
Del 320	1355807	G97359	00928	20/13	5	20	6.2	3.11	X	Win	X	EM3	X	X	X
Del 310	1293406	G97328		80/53	4	12	6.2	3.11	X	Win	No	No	X	X	X
Del 310	1449068	G97350		80/58	4	12	6.2	3.11	X	Win	No	EM3	X	X	X
Del 310	1242180	G97304		80/58	4	12	6.2	3.11	X	Win	No	No	X	X	X
Del 310	1242036	1293311		40/8.2	4	20	6.2	3.11	X	Win	No	EM3	X	X	X
Unisys	G26371	G97354	00609	80/26	5	16	6.2	3.11	X		No	EM3	X	X	X
Del 310	1352113	1009269	00104	80/58	4	20	6.2	3.11	X	Win	No	EM3	X	X	X
Unisys	G25350	1009320	02791	33/8	3	16	6.2	3.11	X	Win	No	EM3	X	X	X
Unisys	G98598	G97302	01134	42/8	5	16	6.2	3.11	X	Win	No	EM3	X	X	X

Notes:

G26371 has no extra Com ports and will need a bus mouse.
G25350 has no extra Com ports and will need a bus mouse.
G98598 has no extra Com ports and will need a bus mouse.

Software Comparison

There were three manufactures of CIM software selected for evaluation. The three manufactures selected were INTERCIM based in Minneapolis, Minnesota; CINNET is produced by J.N.L Industries based in Robesonia, Pennsylvania; and CADCAM Integration based in Woburn, Massachusetts. The comparison was based on the common features of the software's and the unique features offered by each company. Selection of a software to test was based on the software's compatibility with the needs of EM at NASA-JSC.

Common features of the software include NC file transfer to and from the machine. The transfer also includes the software's ability to drip feed a machine a file that is larger than the machines memory without interruption. All the software's ultimately support the concept of a paperless exchange of information on the production floor. The information on the production floor that becomes paperless are tool lists, setup instructions, NC programs and part display images by item managed file systems. The three companies did support their software with training and technical support. The machine operator does have the ability to edit the NC program and redline changes on the drawing at the computer. Databases are used by all three software's to compile information on program files, drawing files, tool lists, and images of parts to be produced. Administratively the benefits of the CIM software's is the ability to track work in progress, statistical analysis on processes, generation of activity reports, and produce accountability for work completed.

Unique features of CIMNET include the following options. Hot keys are offered to speed up the work at the hub (computer) next to the machine. CIMNET is completely ISO9000 compatible and uses password authentication for file access. The machine operator can view the files being transferred when the transfer is active. Anyone using CIMNET can view side by side the NC program that was fed to the machine tool and the program that was up linked back into CIMNET. The most unique feature that CIMNET offers is the ability to archive machine tool setups with audio and video. This can be done if a part is to be made in the future. The machinist can record the setup procedure and it can be down loaded in the form of audio and as many as 32 digital pictures.

Unique features of INTERCIM include such options as machine operator hot keys to speed computer operations and the ability of the operator to see the file transfer as it is happening. The rest of INTERCIM's options were covered under common features of the CIM software.

Unique features of the CAD/CAM software is that it is ISO9000 compatible and it does offer password security. The rest of CAD/CAM's options were covered under common features of the CIM software.

Software Comparison for CIM Application

Shearrow		File Transfer			Paper on Floor			Menu Options				Other		On The Floor			On The Floor		
7/7/95	Name	To	From	Drip Feed	Prg.	Tool List	Pict. Any	Win	Hot Key	Edit	Help Scrn.	train.	ISO	edit	See trns	File Com	Pass-word	File S/S	Red Line
	FTP	X	X			X	X					DOS/ NT		DOS					
CIMNET	DNC Jr.	X	X	X		X	X	X	X	X	X	DOS/ NT	X	X		X	X		
CIMNET	DNC+	X	X	X				X	X	X	X	Some	X	X	X	X	X	X	X
CIMNET	DNC+/w Lite	X	X	X				X	X	X	X	Yes	X	X	X	X	X	X	X
CIMNET	DNC+/w Fldrs	X	X	X				X	X	X	X	Yes	X	X	X	X	X	X	X
InterCIM	F-net Entry	X	X	X		X	X	X			X	Yes				X			X
InterCIM	F-net Inter.	X	X	X				X		X	X	Yes		X		X			X
InterCIM	F-net Advncd	X	X	X				X	X	X	X	Yes		X	X	X			X
CAD/CAM	DNC500	X	X	X		X	X			X	X		X	X					
CAD/CAM	DNC500/w Cell	X	X	X				X		X	X	Yes	X	X			X		
CAD/CAM	DNCII	X	X	X				X		X	X	Yes	X	X			X		X

Name: Software's name.

File Transfer:
- To: Moves files to the server.
- From: Moves files from the server.
- Drip Feed: Moves NC programs as needed.

Paper on Floor:
- Program: NC program in written form.
- Tool List: List of tools need for the job.
- Pict. Any: Images supported at workstation.

Menu Options:
- Win: Functions in Windows 3.1 or 3.11
- Hot Key: Is the menu accessible by short cuts.
- Edit: Can the program be edited.
- Help Scrn: Are there help screens available.

Other:
- Train: Is there training necessary to run the system.
- ISO: Is the software ISO9000.

On The Floor:
- Edit: Editing at the workstation.
- See Trns: Observation of file transfers.
- File Com: Comparison of files and flagging.
- Password: Station and file password authentication.
- File S/S: File comparison side by side.
- Red Line: Operator notes on drawings or pictures.

Software Comparison for CIM Application

Shearrow		Other			Use of Database			Administrative			Setup Information			Computer Requirements		
7/7/95	Name	Tech Supp	View Grph	Item Mang. File	Program files	Drawing files	Tool files	WIP Track	Stats.	Activity Reports	Audio Setup	Pict. Setup	Audit Setup	HD meg.	RAM meg.	CHIP
	FTP													40	2	286sx
CIMNET	DNC Jr.	X												40	4	386sx
CIMNET	DNC+	X	X											40	4	386sx
CIMNET	DNC+/w Lite	X	X	X	DBIV	DBIV	DBIV	X						200+	8	486dx
CIMNET	DNC+/w Fldrs	X	X	X	DBIV	DBIV	DBIV	X	X	X	X	X	X	200+	16	486dx /586
InterCIM	F-net Entry	X	X		X	X	X							100	4	386sx
InterCIM	F-net Inter.	X	X		X	X	X	X						200+	6	486dx
InterCIM	F-net Advncd	X	X	X	X	X	X	X	X	X				200+	16	486dx /586
CAD/CAM	DNC500	X												40	4	386sx
CAD/CAM	DNC500/w Cell	X	X		X		X			X				40	8	486dx
CAD/CAM	DNCII	X	X	X	X	X	X	X	X	X				200+	16	486dx /586

Other:
Tech Supp: Technical support for the software.
View Grph: Graphics viewed at the workstation.
Item Mang. File: Files managed by software.

Use of Database:
Program files: Files stored and tracked.
Drawing files: Drawings stored and tracked.
Tool Files: Tooling lists stored and tracked.

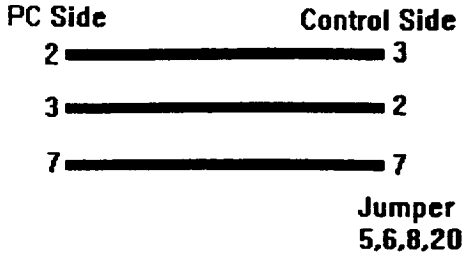
Administrative:
WIP Track: Work in progress tracking.
Stats: Statistical analysis of the operation.
Activity Reports: Generation of activity reports.

Setup Information:
Audio Setup: Audio recording of the procedure.
Pict. Setup: Deliver setup pictures at the workstation.
Audit Setup: Track the setup progress via remote.

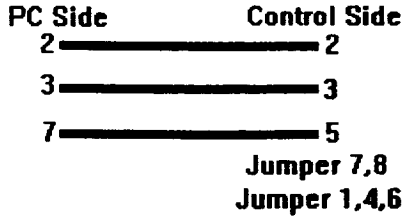
Computer Requirements:
HD meg.: Size of the hard drive in the workstation.
RAM: Size of the RAM to be available.
Chip: Type of processor classification.

Machine to Computer Connections

There are two common machines used on the production floor in building ten. The first is the MAZAK which can be connected with a 25 pin shielded cable that has the following pin configuration.



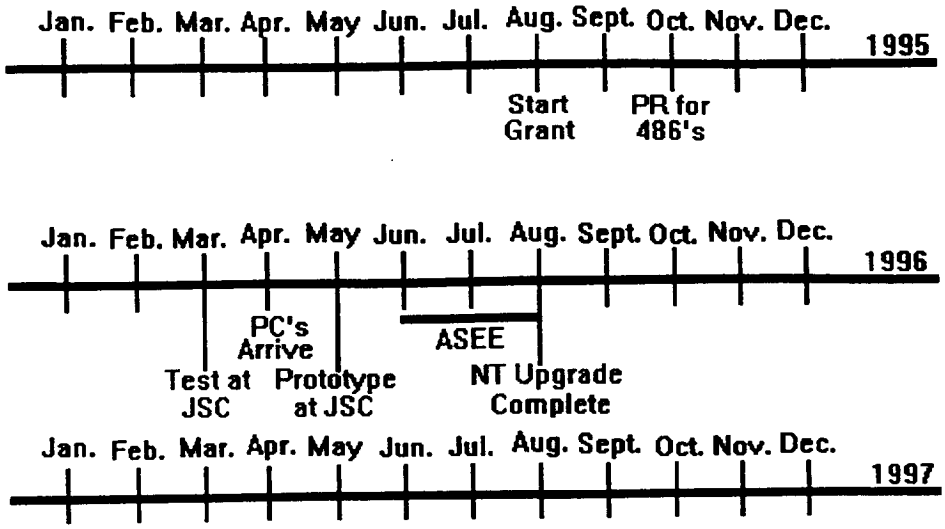
The second most common machine on the production floor are the Hurco milling machines. They can be connected from the computer to the machine with the following pin configuration. It must be noted that one end of the shielded cable must be 25 pin and the other end going into the machine is 9 pin.



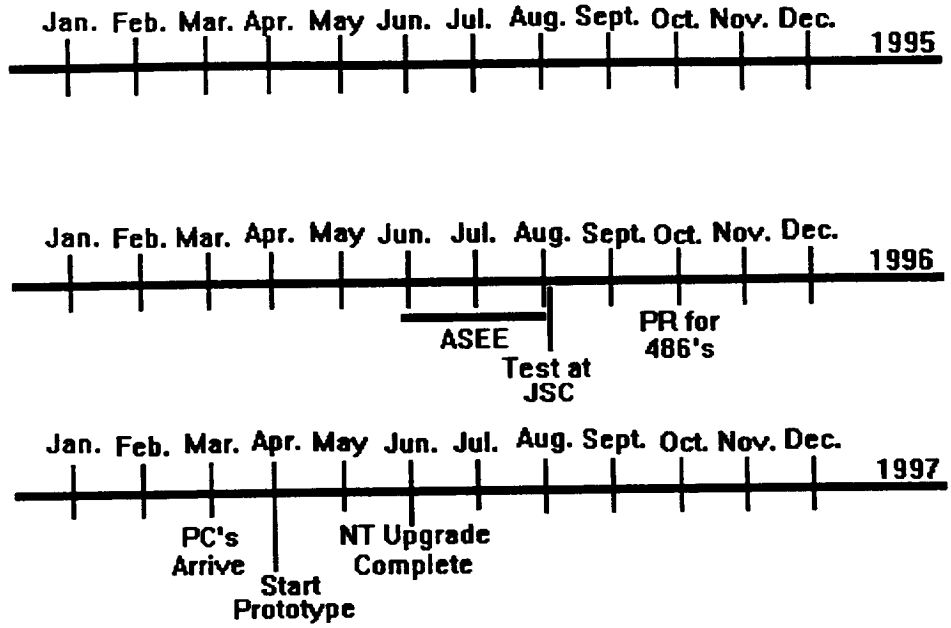
Time Line

Two timelines for implementation of the CIM application have been constructed. The first timeline takes into consideration a grant to continue the development of the CIM application at NASA-JSC during the 1995 academic year. This timeline is considerably shorter that the second time line which was constructed without a grant to continue the work on the CIM application during the accademic year. The second timeline also depends on NASA personnel to do the final phase of implementation.

With A Grant



Without A Grant



In comparing of the two time lines it can be seen that with a grant from NASA it will be possible to bring the CIM technology on line a year before it could be brought on line by doing it in house. Another advantage of using the grant to get the work done is that there are fewer NASA employee hours related to the project and less disturbance to production activities.

Cost Estimate

The estimate for the cost of the software can be broken into two main sections consisting of expenses during this fiscal year and expenses during the 1996 fiscal year. During this year the estimated cost of the CIM software is $16,795.00. This price includes installation of the CIMNET software, training of EM's personnel, and a one year maintenance contract on the software for a 20 concurrent users license. To upgrade the software during the 1996 fiscal year bringing on line all the options needed to fully automate this CIM operation an additional $32,300.00 will have to be spent. This final step will include managerial reports, statistical evaluation of the facilities functions, job tracking, and tool monitoring. There is no cost estimate for the upgrade computers due to the rapid changes in computer prices.

Recommendations

1. Build the network recommended in building 10 that will support connectivity between machines and the NT server.
2. Purchase and implement the CIMNET software (DNC+ w/Folders Lite) and select and configure recycled computers from R&U.
3. Develop a limited NT workstation for the production floor limiting the use of the computers to business only.
4. Integrate the CIMNET software (DNC+ w/Folders Lite) with the NT workstation and test the configuration to insure computability before disrupting production.
5. Replace the 386sx computers with 486dx computers running at 66Mhz or faster. The RAM in the replacement computers must be at least 16 meg. The HD should not be any smaller than 500Meg. with a built in video 1Meg. memory.
6. Install an additional 7 computers so each machine has its own computer. This should eliminate any waiting that could occur during peak use times.