A Paradigm for Success in the Increasingly Competitive Global Marketplace

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Abstract:

The global marketplace for manufacturing of electronics has become increasingly competitive and promises to become even more so as time progresses. Many of the U.S. companies which have traditionally relied upon the government and defense sectors to provide income are now being forced to compete for the consumer dollars necessary to replace the declining federal dollars. The government contractors have traditionally been able to get large amounts of research and development funding or work on a cost plus basis. Now, those same contractors must compete for jobs with manufacturers from all over the world to include Japan and the European community. In order to remain competitive, U.S. manufacturers must utilize the abundant resources of the information age to reduce costs and improve efficiency in all aspects of their enterprise. The increasingly lower cost and greater ease of use of computer resources and the benefits gained by their integration into the workplace make these resources a prime way to reduce costs and increase competitiveness in today's increasingly competitive global marketplace.

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Introduction:

The global marketplace for manufacturing of electronics has become increasingly competitive and promises to become even more so as time progresses. Many of the U.S. companies which have traditionally relied upon the government and defense sectors to provide income are now being forced to compete for the consumer dollars necessary to replace the declining federal dollars. The government contractors have traditionally charged whatever was necessary to complete the job since the government would basically pay whatever the cost necessary to do the job. Now, those same contractors must compete for jobs with manufacturers from all over the world to include Japan and the European community.

In order to remain competitive, U.S. manufacturers must utilize the abundant resources of the information age to reduce costs and improve efficiency in all aspects of their enterprise. The increasingly lower cost and greater ease of use of computer resources and the benefits gained by their integration into the workplace make these resources a prime way to reduce costs and increase competitiveness in today's increasingly competitive global marketplace.

Background:

The increasing use of computers in the workplace over the past 10 years has led to one of the most revolutionary increases in worker productivity ever seen in the history of man. The use of personal computers and workstations have reduced many labor intensive tasks to a few simple keystrokes on a keyboard. Many companies have invested heavily in computer technology to increase productivity while other have either failed to invest where necessary or have invested only enough to fool themselves into thinking that they are fully computerized.

The areas which have seen the most dramatic increase in productivity are mechanical drafting and design where the pencil and drafting table have become virtually extinct and manufacturing control where there is a PC in control of almost every piece of equipment being marketed today. The introduction and use of Computer Aided Design (CAD), Computer Aided Engineering (CAE), Computer Aided Manufacturing (CAM), and Computer Integrated Manufacturing (CIM) have become synonymous with the formula for success in the increasingly competitive business world.

The push towards total integration of all information sources and the ability to access this information will eventually lead to a separation of those companies who are able to fully integrate themselves into a totally information based enterprise versus those companies who will struggle to exist in an isolated mode with islands of non-integrated automation. The current push towards Total Quality Management (TQM) within industry depends upon everyone in the enterprise communicating with each other and knowing what is going on throughout the company. A company which has invested in integrating themselves totally from a systems standpoint will have a much easier time of keeping all of its people informed and working towards the same goals.

Evolution of Systems Architecture:

The use of computers in the 1960s and 1970s was basically limited to large mainframe systems which were fed information through stacks of punch cards by specially trained individuals who operated the systems and handled all of the hardware related interfacing. Programming was done by specially trained individuals who spent their entire life immersed in the computer world and spoke different languages from the majority of the civilized world. (These people would later come to be known as nerds and in some cases, these nerds would then become millionaires.)

Due to the difficulty of interfacing with computers during the 60s and 70s, they were mostly used for repetitive tasks such as accounting and finance related activities as well as record keeping and large number crunching functions (primarily related to scientific applications).

As we moved into the 1980s, the birth of the personal computer or PC started to bring the power of computers to the ordinary individual. Not only were computers now affordable and easily accessible, but there were now programs written with user friendly interfaces thus allowing anyone to be able to access the power of the computer. Businesses were now able to use computers routinely for tasks such as word processing, accounting, graphics related activities, database generation, and other day to day activities. Companies which invested in the new PCs saw dramatic increases in productivity through the ability to easily perform such tasks as mass mailings of form letters, playing "what if" simulations on spreadsheets, and quickly accessing thousands of pieces of information on easy to use database programs. We could now afford to put a PC on each individual's desk so there was no longer a problem with vying for the limited resources of a single mainframe in the company since the PCs could outperform many of the older mainframes and cost about 1/100th of the price.

The Growth of Networks:

The proliferation of PCs and workstations in the workplace has led to a phenomenon similar to what occurred with larger computers during their evolution. Initially, larger computer use was limited to only those people capable of understanding how to use the systems. This later changed as software was written which enabled non-technical people to use the systems. The introduction of remote terminals for accessing the computers eventually led to the demise of the card punch method of data entry and the remote terminal began appearing on desktops throughout companies. As the terminals proliferated, the inability of the large systems to keep up with user demand for a portion of CPU time (time sharing) led to longer and longer delays for the users. Continual upgrades to the system hardware became necessary along with the fact that each new user had to be trained in the use of the system.

Just about the time that the crunch of users was starting to bog down the larger systems, the introduction of the PC came about in the workplace. Now it was possible for each individual user to have the power of the computer at his or her desk with software written specifically for the task at hand (ie.. word processing, databases, graphing of data, etc.). Initially, everyone was ecstatic since it was now possible to have your own computer whenever you needed it, access time was virtually instantaneous (no more time sharing problems), and software was relatively inexpensive and easily available (compared to software for the large systems). As we moved into the mid and late 1980s, it became obvious that users had a need to share information between desktop computers in a more efficient way than physically exchanging copies of floppy disks or sending files with simple communications packages across modems. A system was need whereby a single copy of any given file could be accessed by any user and browsed or worked on. This situation led to the proliferation of Local Area Networks (LAN) and Wide Area Networks (WAN) across which many users could share information and even copies of a single executable program. Eventually LAN servers were set up to take advantage of the ability to provide high powered computing capability and disk storage space to anyone on the network.

Although it appears that we are going full circle back to the days of terminals tied in to mainframes, there are some major differences. It is no longer necessary to depend on the mainframe or server for your executable programs, storage space, or computing power. An individual user can determine their own dependence on the network and configure their PC/workstation to whatever level of dependence is required. Each user can also chose their own software packages based upon personal needs and preferences since there are numerous data translation packages available which make it very easy to pass data between various programs.

Integration of Systems:

As we move into the 1990s, the information age is at the point where we can finally communicate between most of our computer systems with relative ease. The emergence of both hardware standards such as RS-232, and the Hayes instruction set for modem communications as well as software standards such as "dBase compatible", "Lotus compatible", and the well known ASCII format allow us to use just about any program without having to worry about how we can later use the information in another program. Many software vendors such as Oracle and Lotus are even providing mainframe and PC version of their software to increase exchangeability of data and lead to smoother integration of all level systems. Many software vendors are also distributing versions of their software capable of running on both Macintosh and IBM compatible systems to accommodate those installations with a divided user base.

Many companies and even individuals are now tied in to electronic mail (E-mail) systems which allow instantaneous transmission of text messages and even binary files to any point on the globe for pick up by other individuals with E-mail accounts. Although there are numerous E-mail systems, there are attempts underway to link all of the systems together via a common standard such as the CCITT X.400 standard so that messages may be sent from one E-mail system to another, invisible to the user, in much the same way that we currently use the telephone to talk between phones hooked up to MCI, US Sprint, or AT&T to name but a few.

In the same way that standards exist for exchanging data between programs and E-mail systems, standard protocols are also being set up to handle manufacturing equipment. Standards such as Standard Equipment Communications Standard II (SECS II) and the Surface Mount Equipment Manufacturers Association (SMEMA) standard for communications between microprocessor controlled equipment are being adopted by an ever increasing number of equipment vendors in the manufacturing area. This equipment standardization will alleviate the need for multiple controllers on the factory floor and thus greatly simplify the integration of manufacturing systems under a common computer and operating scenario. In the event that a piece of manufacturing equipment is not standardized and yet still needs to be controlled from a computer based environment, there are numerous products available to interface via hardware and software and thereby control a manufacturing cell. Figure 1 looks at just a few potential vendors capable of assisting in the integration of a manufacturing environment.

Real Life Examples:

Now that the pieces are in place to provide an integrated solution, how do we effectively implement the solution to provide maximum productivity and efficiency? Let us look at the manufacturing process from beginning to end (figure 2). A customer defines a set of requirements for what they would like built. We will use a Printed Wiring Assembly (PWA) as an example. The requirements are given to electrical engineers who design the circuit on an Apollo workstation and provide a string list and special requirements for use by the mechanical engineers. The mechanical engineers, working on Computervision terminals develop the physical layout of the assembly and generate a parts list for manufacturing and files to be passed to a draftsman for generation of artwork files. Mechanical engineers also do thermal and mechanical analysis of the design using software residing on both microcomputers (PCs) and also on the VAX and the Cray supercomputer. The artwork files are passed to a Laser Artwork Generator (LAG) where the actual artwork for manufacturing the physical Printed Wiring Board (PWB) is generated. NC tape information is also sent to the machine shop for use in fabricating the metal parts required in the PWA. The parts list is used by manufacturing and purchasing to order what is necessary for the actual assembly of the end item. Manufacturing generates a data file which is used in the assembly area for driving different pieces of computer controlled manufacturing equipment. Data gathered from the manufacturing operations as well as inspection data obtained from a PC based Voice Data Entry (VDE) system are fed to a database which stores this information for future analysis.

Another example of integration uses PCs to provide quick turn around in a development environment (figure 3). Electrical and mechanical layout of a PWA are done on a PC using AutoCAD and the resulting file is converted to IGES (International Graphics Exchange Standard) format by AutoCAD for transmission to the LAG via a link with the VAX. The LAG then generates the required artwork to fabricate the PWB. A second program is used on the AutoCAD data file to generate a drill file for use on a PC controlled NC drilling station for drilling and routing of the completed PWB. A third program is then used to generate placement data directly from the AutoCAD file for use by a pick and place machine. By using all PCs (With the exception of the VAX to serve as a data link to the LAG.) in this environment and having all of the end systems able to work from AutoCAD data and similar disk formats, we can go from concept to completed product in a matter of days instead of the normal turnaround time of several weeks.

Yet a third example of the use of PCs involves using them to gather temperature profile data from an InfraRed oven used to reflow solder during an assembly operation. The software used to gather the temperature data (Labtech Notebook) is easily setup to gather all of the data in whatever form is needed and then automatically sends the data to an ASCII file which is readable by one of the many spreadsheet packages on the market. The Labtech software contains commands which allow the user to shell out directly to the spreadsheet program for data analysis even while data is still being gathered in the background.

In the above examples, many of the systems are linked together and yet several of them are still islands of automation in the overall process. It is these islands of automation which must be linked together to form a completely integrated environment from the initial requirements definition to the feedback of manufacturing information for impacting future designs. The successful enterprise will be one where all of these elements are totally integrated and allow all of the information to be available to anyone who needs it in a form which they can understand.

Enterprise Integration Programs:

The US Government is heavily involved in helping American industry to meet the challenge of standing up to foreign competition and react to the internal slowdown in defense dollars by providing money to help industry become information oriented and fully integrated. Programs such as the Defense Advanced Research Planning Agency (DARPA) Initiative in Concurrent Engineering (DICE) and the US Air Force's Advanced Quality Engineering System (AQES) have been funded to develop the means for a totally integrated enterprise. Figure 4 shows the integration level proposed for a full implementation of the AQES program to include tie in to virtually every level of the design and manufacturing environment. In addition to the DICE and AQES programs, there are also numerous other initiatives both internal to many corporations and externally funded throughout industry with the sole purpose of reducing costs and increasing productivity through the integration of information throughout the total enterprise.

Conclusions:

The pieces are in place to achieve a totally integrated enterprise, the job now is to commit to the integration itself. Virtually every desk now contains some variety of PC or workstation capable of accessing others other systems via LAN, WAN, or modem. Equipment manufacturers are beginning to look at standardizing access to machine control to allow for ease of interconnection and software standards allow for transfer of data between various programs. By committing the resources necessary to identify the pieces of the integration puzzle and how to put those pieces together, we can develop a fully integrated enterprise. This enterprise will fully utilize the potential of both large systems such as IBM and VAX as well as PCs and workstations. People at any point in the enterprise will be able to instantly access information from any other part of the enterprise and in will only be necessary to maintain a single copy of any piece of information.

As the current generation of students reaches the workplace, they should come to expect the instantaneous accessibility of all information pertaining to their job. The work being done now in putting information at the fingertips of the users will pave the way for a highly productive and efficient enterprise which is capable of competing in the global marketplace of the 21st century and successfully winning against all competition.

Major Criteria	Cell Control Class	Monitoring Class	Specialized Class	Traditional Computer Language Class	Shop Floor Control Class
Vendors	FASTech CELLworks, Savior, Honeywell, American Cimflex, Dacscan	Intellution, US Data, Heuristics, GEF	Alien-Bradley PLC, GEF CNC, Adept Robot Controller	DEC VAX, IBM OS/400, HP 1000, Tandem, Stratus	NREC, Consilium, Denniston, Westinghouse, Unicell XL
Hardware	PC or minicomputer with open bus	Primarily PC	Proprietary	Primarily minicomputer	PC or minicomputer
Operating System	Real time, multitasking, multi-user, deterministic	Primarily DOS plus proprietary extensions	Proprietary, embedded executive	Multitasking, multi-user, non-deterministic	Multitasking, multi-user, non-deterministic
Primary/Secondary use	Cell control/process monitoring and data collection	Monitoring/supervisory control	Device or process control/communication to attached devices via application software	General purpose computer/specific purpose via custom application code	Shop floor management/data collection
Cell Control Programming	Graphic, modular, object-oriented, English statements plus C/PASCAL	Limited for coordination control;subordinate to graphics/MMI	Ladder, function blocks or proprietary statement; subordinate to device control	C, PASCAL, low level linkers	Limited cell control development capability
Database Capabilities (real time, on-line transactional)	Yes, relational and real-time, with integrated third party databases	Yes, flat files and tagging	Some, tables and registers or contained in motion functions	Yes, custom integration with third party software	
Host connectivity	Yes, available for most popular networks	Yes, some	Yes, limited	Yes, custom	
Architecture	Object-oriented with application development tools	Central flat file and polled I/O points	Motion and I/O control	Procedural software development environments	User configurable data base applications

Figure 1 Approaches to Implementing Cell Control[1]

[1]Information provided by FASTech Integration Inc., Waltham, MA

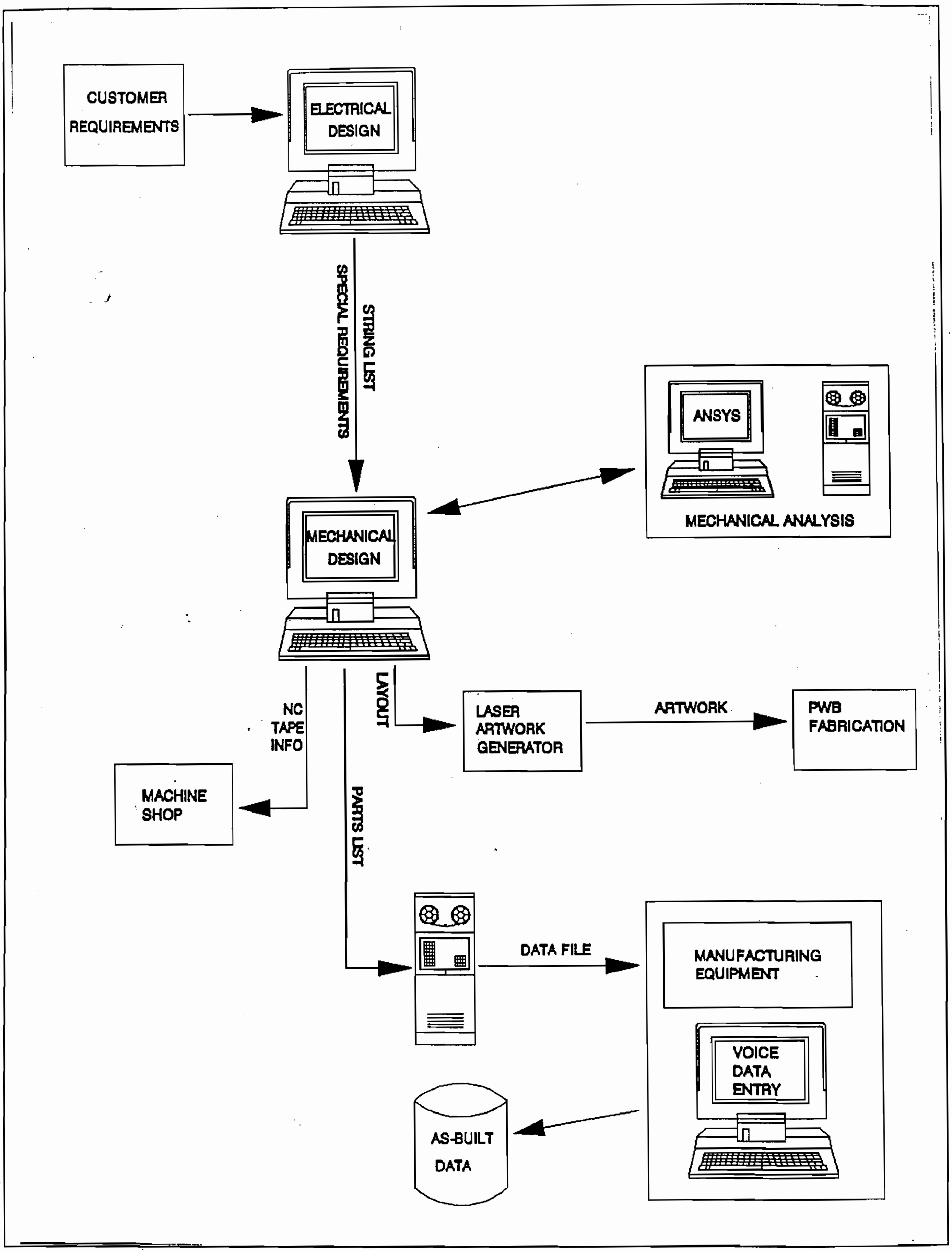

Figure 2 The Manufacturing Process for a PWA

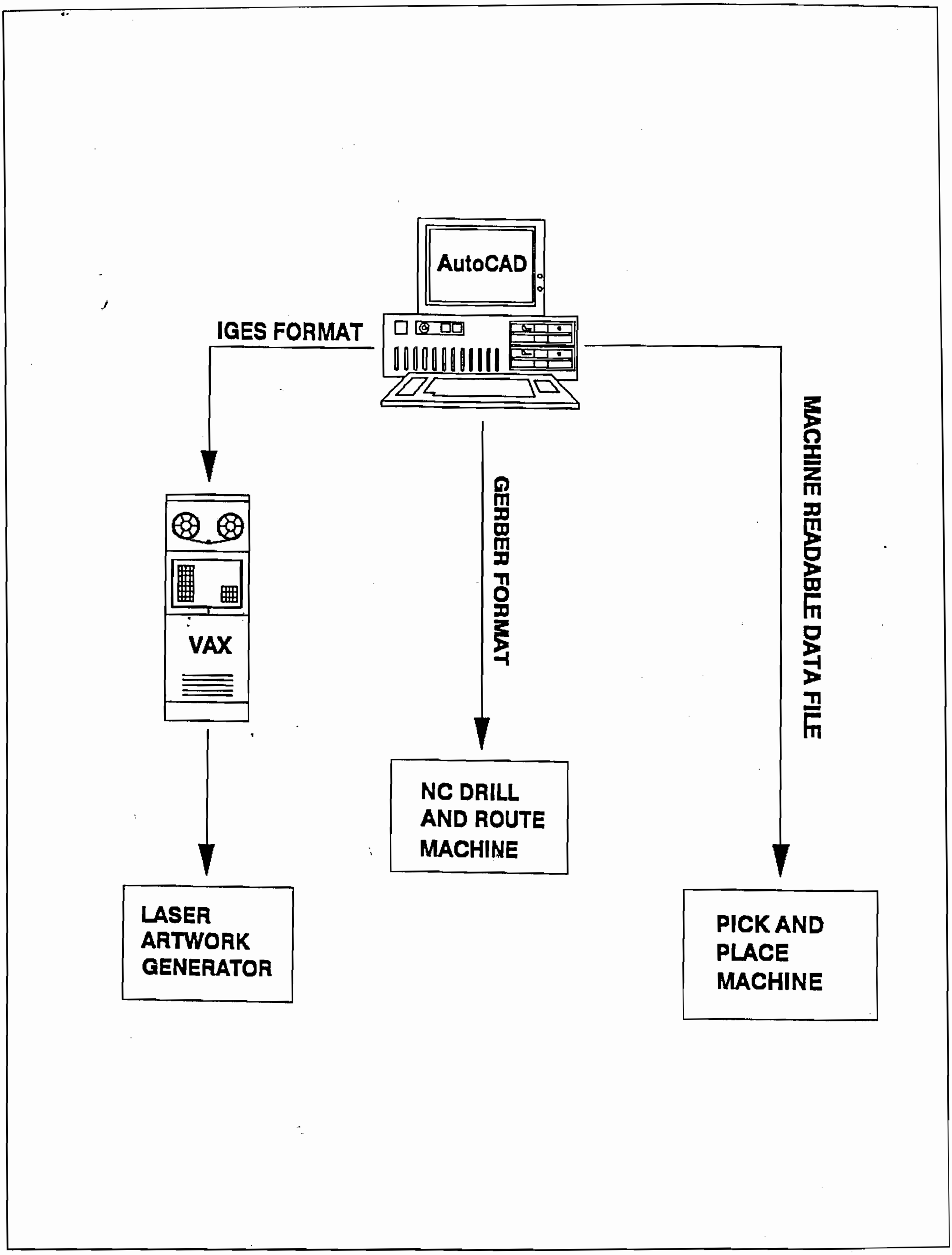

Figure 3 The Use of PCs in a Development Environment

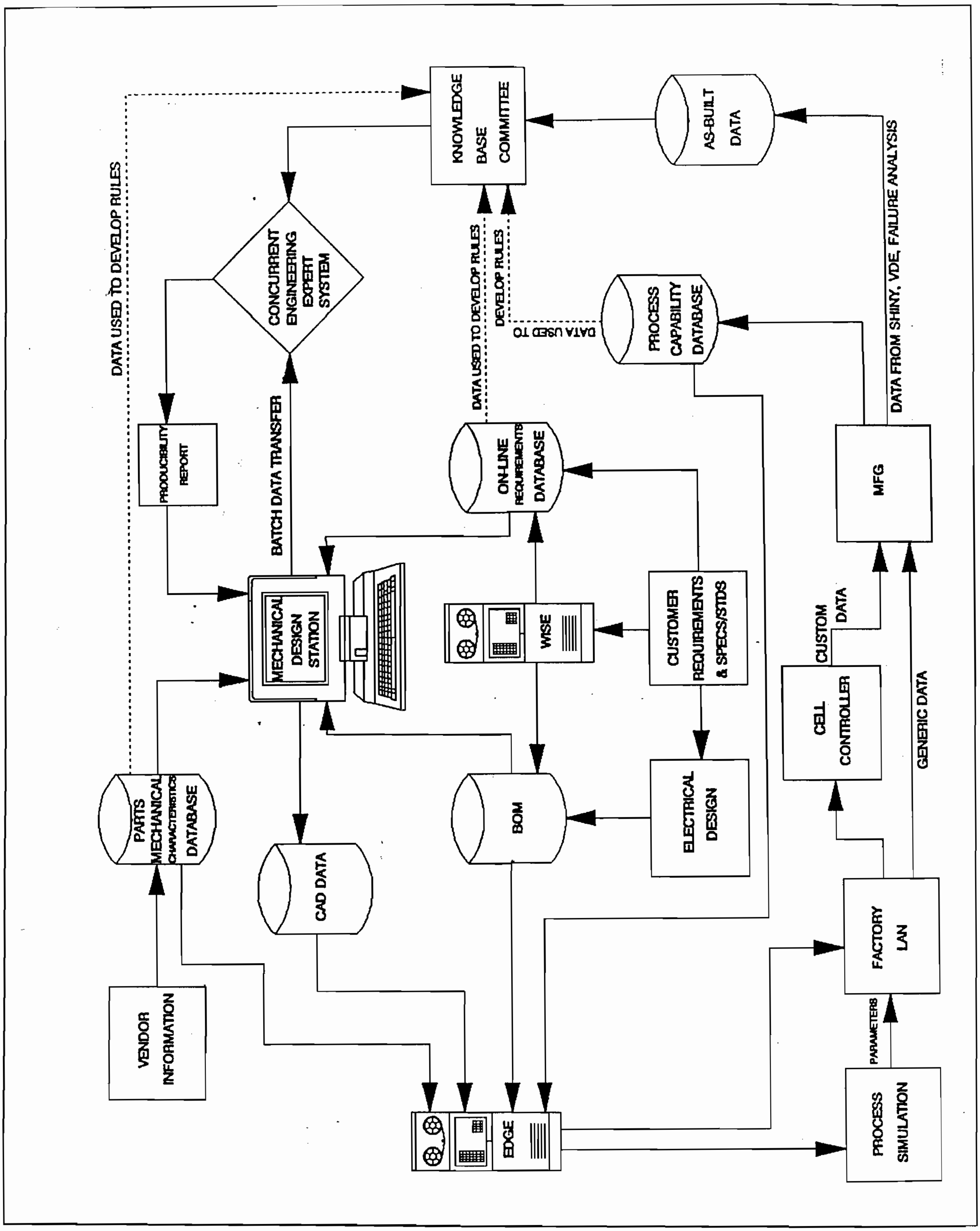

Figure 4 Architecture Planned for Prototype Implementation of AQES Program