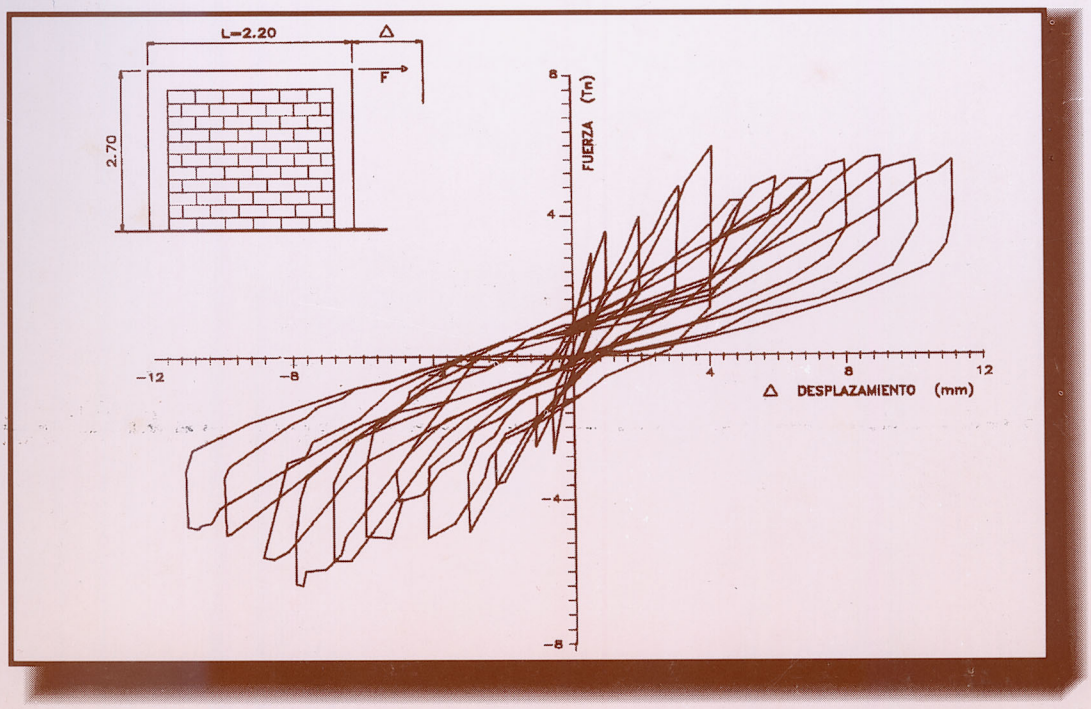
Ingeniería

Revista de la Universidad de Costa Rica
ENERO/JUNIO 1995 VOLUMEN 5 Nº 1



Ingeniería 5 (1) : 79 - 89 1996 San José, Costa Rica

A SUGGESTED PLAN FOR THE IMPLEMENTATION OF CAD/CAM SYSTEMS

Luis Rapso/UCR
Alvaro Montoya/ITCR
Javier Bonilla/INA
Alberto Morales/Moldes Ind. S.A.

Summary

This document is the result of the internship done in Universal Instruments Co., Binghamton, N.Y., as a part of the AID/CINDE (Costa Rica) CAD/CAM and CNC Training Program, sponsored by Broome Community College. (July through Aug. 1994)
Its objective is to present a general plan for the implementation of CAD/CAM systems and is focused on the machining processes of companies in Costa Rica and the Central American area. However, the presented considerations and recommendations, due to their general character, are applicable to any machine shop.This plan was developed based on an analysis done on the Universal Instruments Co. system.

Resumen

Este documento es el resultado de la psantía realizada en Universal Instruments Co., Binghamton, New York, como parte del Programa de Entrenamiento de Corto Plazo en CAD/CAM y CNC auspiciado por AID/CINDE (Costa Rica) y Broome Community College. (Julio/ Agosto. 1994)
El objetivo es presentar un plan general para la implantación de sistemas CAD/CAM y esta direccionado a los procesos de mecanizado de empresas en Costa Rica y del área centroamericana. Sin embargo, las consideraciones y recomendaciones presentadas son aplicables a cualquier instalación dado su carácter general. Este plan está basado en un análisis realizado en el sistema de Universal Instruments Co.

1. INTRODUCTION

To get and maintain a competitive level in the present market, manufacturing companies must update their processes by acquiring new systems and technologies. Small machine shops, in particular, are in a race against time, and very often commit expensive mistakes: inappropriate implementation of technology is one of them.

Owners often waste money by purchasing sophisticated machinery without knowing why. Therefore, many companies cannot utilize the CNC machinery, which they have purchased, in a cost-effective manner.

Even though there may be no specific procedures for implementing a CAD/CAM system, there are a series of considerations that must be taken into account to get a cost-effective system.

With the objective of providing a base for appropriate spending of resources, this document contains those considerations, organized as a general plan, which are recommended particularly for small machine shops.

2. THEORETICAL BASE

The first question that any company must answer before starting the implementation of a CAD/CAM system is:
Do we really need a CAD/CAM process?

Often, people make the mistake of acquiring technology in response to market forces and provoking companies into spending money for purchasing equipment. This represents either a very long term profit or perhaps, a non-profitable investment. Frequently, people think that technology - by itself - is going to solve the production problems that their companies have and increase the profits from their processes.

Actually, what must be considered is that no matter the sophistication of the technology, it's only a tool that must be used (in the correct way) in order to get the results you expect.

Before making the decision of implementing CAD/CAM process the following items must be considered:

1.What is CAD/CAM ?

2.Does our process require a CAD/CAM system?

3.What is the expected expansion of our process?

4.What do we need in order to integrate the system?

5.What is the real profit from that this integration represents?

6.How long will it take us to recover this investment?

2.1What is CAD/CAM?

The meaning of the term is: "Computer Aided Design & Manufacturing". But in practice, the concept involves a whole organizational structure which supports the production process.

A CAD/CAM process can be described as a productive cells net, all tied to each other by a multi-directional information system. This way, any alteration in one of them is going to generate immediate feedback signals toward the others and, at the same time, these signals will have their corresponding feedback.

On the other hand, the whole system is linked to a quality assurance concept which induces each cell to deliver its best product. (Fig. 1) To attain this system you must carry out the fundamental requirement of developing information media which assure an efficient flow of information.

You must create a database which allows for quick access to information with a minimum of error. Furthermore, each one of the related areas must have a good definition of functions and procedures as do its connections with the rest of the system.

2.1.1 Management

The management of a CAD/CAM process should be characterized by its open-mindedness which really considers the opinion of all members of the team. Its function is basically to coordinate and supply the facilities the team requires.

This position must not be confused with the management of the company, even though the same person(s) may perform both tasks.

Fundamentally, management is responsible for inducing "team working" and developing the "do the best" mind-set for all members.

2.1.2 Design & Programing

These functions are basic, and must start with the absolute understanding of the conditions and capabilities of the system. In other words, persons in charge of these areas must know -exactly- what the system can or cannot do.

2.1.3 Process Planning

This function consists of the coordination between the areas of Design & Programing and the shop floor.

The same way, people in here must know about the system capabilities and the handling of the information channels.

A well done planning determines the process efficiency thus, the profit level and the excellence of the production.

2.1.4 Shop Floor Operations

This is not only the operation of machines but also is the origin of the feedback signals which stimulate the evolution of the entire process. Based on the results and conclusions from the manufacturing process, improvements to the final product are generated.

The shop floor is where quality is defined, so these personnel are responsible for acting as filters for process deficiencies. They must be critically-minded people who have the motivation to do whatever is necessary to get the best product.

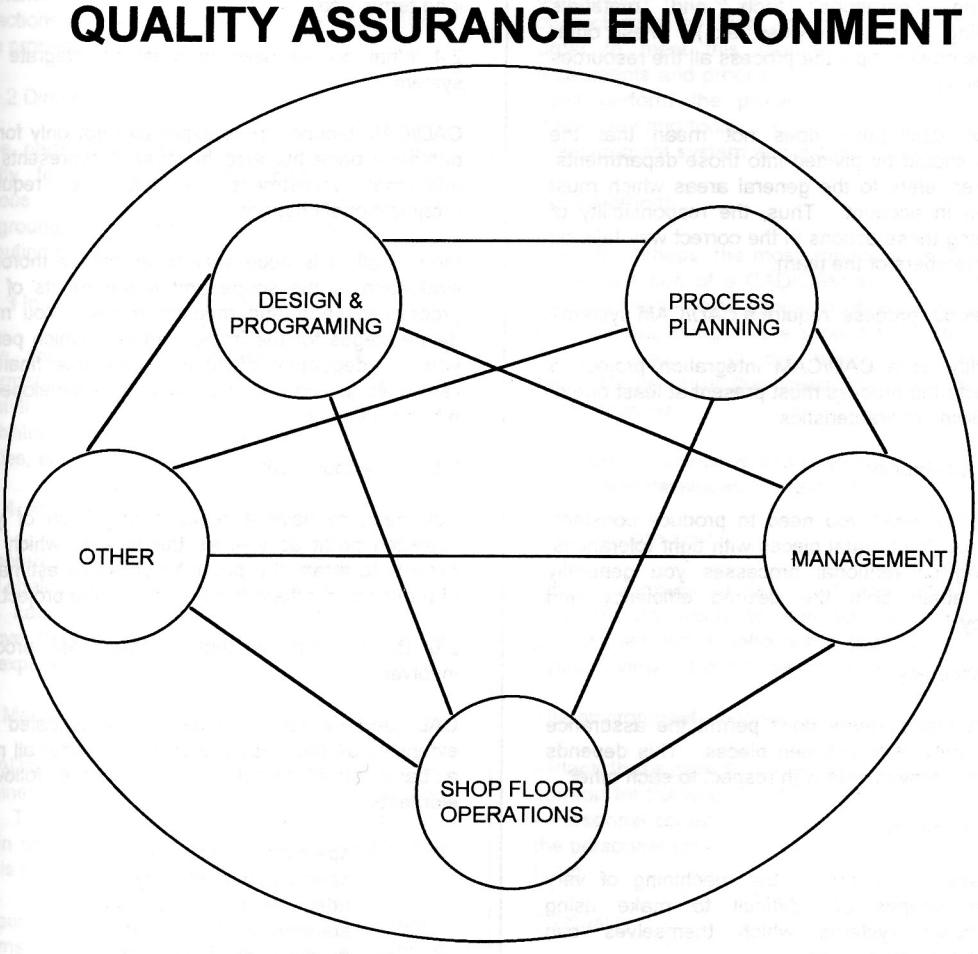


Figure 1 A CAD/CAM system model.

2.1.5 Other Services

The manufacturing process involves many tasks which are not CAD/CAM functions (conventional machining operations, tools and materials purchasing, financial services, etc.). These other functions must supply the process all the resources that it requires

The last description does not mean that the process should be divided into those departments, but rather refers to the general areas which must be taken in account. Thus, the responsibility of performing these actions in the correct way falls on all the members of the team.

2.2 Does our process require a CAD/CAM system?

To qualify as a CAD/CAM integration project, a manufacturing process must present at least one of the following characteristics:

2.2.1 Repeatability

This occurs when you need to produce considerable amounts of equal pieces with tight tolerances. By using conventional processes you generally cannot attain both the desired efficiency and accuracy.

2.2.2 Accuracy

Conventional systems don't permit the assurance of uniformity of fit between pieces. This depends on precise movements with respect to each other.

2.2.3 Complexity

Processes which include the machining of very complex shapes are difficult to make using conventional systems which themselves can increase production costs.

2.3 What is the expected expansion of our process?

A CAD/CAM process can be characterized as an evolutionary process. This means that data found during the process must be conducive toward the development and improvement of the system. You must avoid the mistake of acquiring technology with the only objective of solving a unique production problem. Furthermore, decisions should be based on an objective projection of your future scope, taking into consideration short, medium and long terms goals.

2.4 What do we need in order to integrate the system?

CAD/CAM technology is expensive not only for its purchase price but also because it represents an additional investment to get the required organizational changes.

First of all, it is necessary to execute a thorough evaluation of the scope and requirements of the process in short and medium terms. You must define stages for the implementation which permit you to adequately distribute available financial resources to allow all elements to be developed in a balanced way.

2.5 About profit

You need to have a realistic projection of your expected profit as well as the time in which you expect to attain the profit.A subjective estimation of profit could initiate the downfall of the project.

2.6 Basic elements that a CAD/CAM process involves

CAD/CAM systems can be as sophisticated and extensive as each application requires but all need a basic structure which involves the following elements:

- specialized personnel
- specialized machinery
- adequate metrology systems
- standard work methods
- model work environment

2.6.1 Personnel

No matter how advanced the technology is that you do have, what determines the success of your system are the characteristics of the team. There are four basic areas that must be checked in the selection of personnel:

2.6.1.1 Specific skills

Quantitative characteristics such as mechanical design & drafting abilities, manufacturing process experience, ability to work in the presence of distractions and within a given time frame, ability to solve problems, etc.

2.6.1.2 Directly related aptitudes

Those parts of a user's background that apply directly to the current job abilities such as: previous system experience, good math background, knowledge about the use of computing systems, etc.

2.6.1.3 Indirectly related aptitudes

Those that are not pertinent to the actual performance of a system user's job, but have the potential to enhance the candidate's on-the-job capabilities, such as: language facilities, teaching facilities, effective communication of ideas, etc.

2.6.1.4 Attitude and motivation

All members of the team should be aggressive, enjoy challenges and trust in their abilities. On the other hand, all them should be motivated to improve themselves by learning and increasing their experience.

2.6.2 Machinery

A CAD/CAM process not only requires CNC machinery but also conventional equipment and tools. Thus, you must acquire machinery step by step in order to assure that all the equipment you need is available.

The purchase of machinery, tools and clamping systems are very important points to consider at the definition of the initial investment because the cost of tools could easily exceed the cost of the associated machinery.

2.6.3 Materials

To assure the success of all manufacturing processes it's necessary that good quality and specified materials are available.

2.6.4 Metrology

Processes that normally are performed in conjunction with a CAD/CAM process are often characterized by high accuracy dimensions. In order to meet this requirement you need the instruments and processes to measure them. You can't perform the process by having only the machinery and tools. You need both a well-defined measurement system and the adequate tools.

2.6.5 Methods

This is, perhaps, the most important aspect in the implementation of a CAD/CAM system. A defined and standard methodology must be applied from the very beginning of the project through the last day of work. All the tasks, functions and performances must flow toward the same goal in a timely manner.

Of course, continuous improvement must be a part of any well developed method.

2.6.6 Environment

Once a company has taken into account all considerations, it's ready to generate a model work environment which reflects the organization of the system, viewed from all perspectives.

The environment involves:

- Plant: those aspects which determine the physical comfort for the whole system.
- Personnel conditions: those aspects which favor the personnel satisfaction of all the members of the team.

2.7Quality

You can get as many definitions of Quality as books you want to read but, what a company needs, is to develop its own concept and apply its own policies. Of course, that concept will depend on a fundamental consideration:

What is the customer's concept of quality?

(A good company should go at least one step beyond.)

All the quality philosophies (JIT, TQM, ISO 9000, etc.) are only good ideas until people accept the responsibility of giving the best of themselves. The way to get that behavior cannot be written; it's not a recipe. The only thing a manager can be sure about is that human beings are, basically, reactive entities and they are going to give back the same attitude that they receive. Nowadays, production has become very cold and impersonal. Most of the time, people don't feel themselves as part of something important. Companies must retrieve some of the concepts of the "made by hand" method of working and give people the opportunity of being creative within a technological system.

In a CAD/CAM process, you will get the highest quality when everybody considers themselves as part of the best team and that they are doing valuable work.

3.A CASE STUDY OF A CAD/CAM SYSTEM: UNIVERSAL INSTRUMENTS, BINGHAMTON,N.Y.

The following part of this paper describes how a representative CAD/CAM system runs in a factory. Figure 2 shows a flow diagram, and then the different steps are described.

3.1Design:

In a system approach to a CAD/CAM system the first input is the definition of a need which starts the design process and finishes with a set of drawings, models and specifications fulfilling that need (the CAD part of the process). It leaves the establishment of an order to the manufacturing facility (which develops the CAM part of the process).

3.2 The Order:

The order is the input to the manufacturing process and usually includes the quantity of pieces, blue prints, and other particular specifications . The manufacturing engineering department verifies the capacity to make the work with the available machines. If it is possible, the project is verified in order to establish decisions, with the Design Dept. about changes in the part and simplifications for the process. The different parts are separated in order to make some totally or partially by CNC machines, and the rest by conventional machining.

3.3 Programming:

In this step programs are made in order to machine the different pieces by CNC. Programing can be manual or by computer aided manufacturing (CAM) systems. Manual Programing can be done by manual direct input (MDI) in the machine. Or it can be typed into the computer and then transferred to the machine by disk drive, punched tape, serial port or by DNC (Distributed Numerical Control) -- the most effective way.

CAM programing includes a graphical interface where a model of the piece part is developed. A processor develops a cutter location file which is the base for a CNC program made by a post-processor; these programs can be transferred in the same ways as manual programing except for MDI.

The selection of appropriate tools and fixtures must be done in parallel with the programming in order to develop the process for the piece. It supposes that in some cases the acquisition of new or special tools and/or the design of special fixtures must be considered.

3.4 Simulation:

Simulation is dependent on the graphical capacity of the hardware and software, and permits the verification of the functionality of the program. Usually in this step a modification of the program may be required, and possibly a modification of the design, in order to improve the process. Simulation can be done by 2D or 3D systems as the complexity of the piece requires.

3.5 Prototype:

With the program and the associated information completed, it is now possible to start the prove-out machining of piece parts. Sometimes this prototype is made with other materials such as wood, special wax, polyurethane, etc. or with the specified material. The prototype enables more

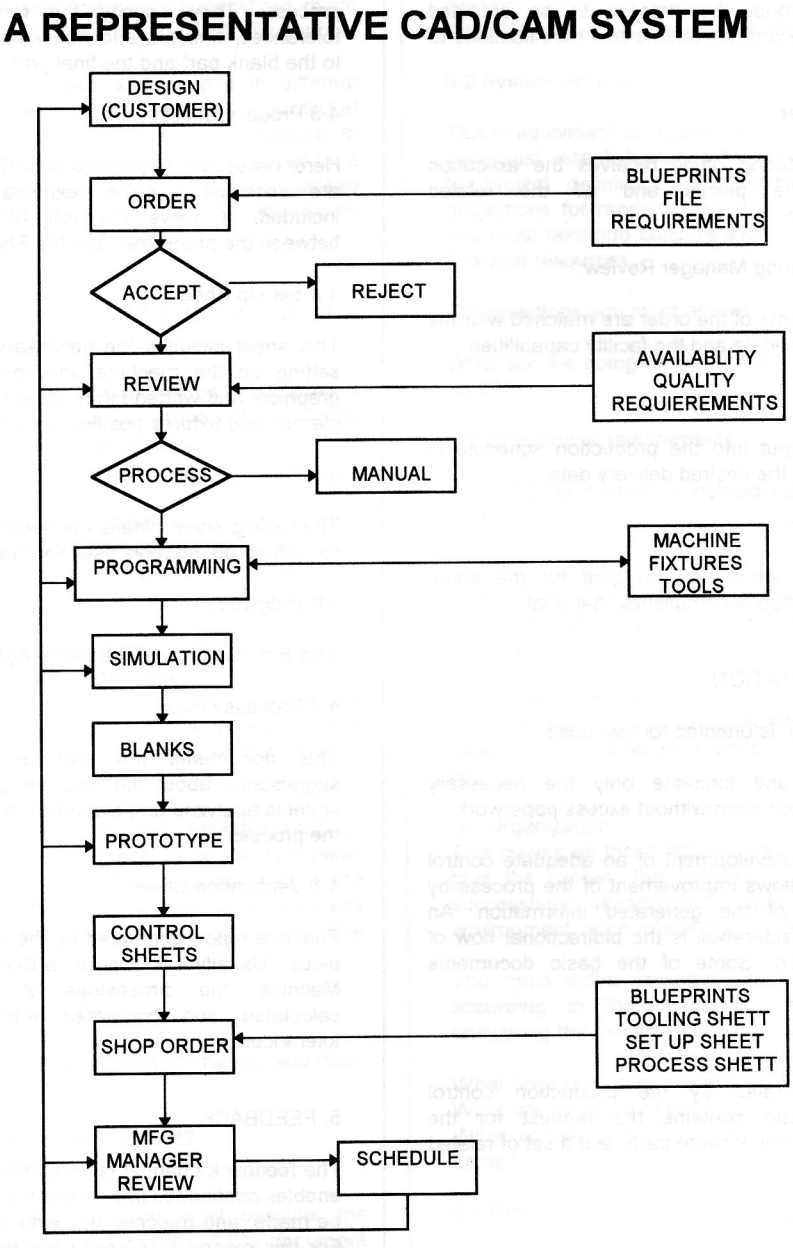


Figure 2 The CAD/CAM system

information about the process to be obtained allowing for recommendations and modifications to the process.

3.6 Shop Order:

The manufacturing office receives the execution order for the pieces and all the related documentation.

3.7 Manufacturing Manager Review:

The requirements of the order are matched with the production schedule and the facility capabilities.

3.8 Schedule:

The order is put into the production schedule in order to attain the desired delivery date.

3.9 Production:

The previous steps set the goal for the entire process; this step accomplishes that goal.

4. DOCUMENTATION

Documentation is oriented for two goals:

i) Generate and circulate only the necessary amount of information without excess paperwork.

ii) Permit the development of an adequate control system that allows improvement of the process by the analysis of the generated information. An important consideration is the bidirectional flow of the information. Some of the basic documents used are:

4.1 Job Order:

This is generated by the production control department and contains the request for the production of one or more parts and a set of related specifications.

4.2 Blue Prints:

These documents are the principal source for the required specifications during the production process. They specify the form, dimensions, tolerances, finishes and additional notes referring to the blank part and the final part.

4.3 Process Sheet:

Here, necessary sequenced activities for machining are specified. Other explanatory notes are included; it plays the roll of communication between the programer and the Shop Floor.

4.4 Set Up Sheet:

This sheet includes the necessary information for setting up the machine and mounting the part; graphical and written information are supplied. The clamps and fixtures position are specified.

4.5 Tooling Sheet:

The tooling sheet details the necessary information for setting up the tools used for machining the part.

4.6 Program List:

This is a hardcopy of the part program.

4.7 Process History:

This documents the part process, collecting suggestions about the machining process. This sheet is analyzed and evaluated in order to improve the process.

4.8 Verification Sheet:

This is a report generated by the verification of the piece. Usually it is done by a Coordinate Measure Machine; the dimensions of the piece are calculated and compared with the specified tolerances.

5. FEEDBACK

The feedback channel is very important because it enables continuous improvements in the process to be made, and matches this with quality principles. For this reason it is necessary that this feedback principle receives management support. Adequate documentation must be circulated during the

process so a rational analysis of suggestions might be made in order to maximize the profit obtainable.

The production process is developed in different stages. Feedback information must be collected at all stages, because every one has something to add. At the next step, information is analyzed by a higher staff level; this is then evaluated and passed to an operative level in order to implement corrective actions to the process.

6. STRATEGY FOR THE IMPLEMENTATION OF A CAD/CAM SYSTEM

The following strategy must not be considered a specific procedure but a group of principles recommended for implementing a CAD/CAM system.

This strategy must be adapted to the specific conditions that each machine shop presents. Specific operational tactics must then be developed according to the needs of the specific processes.

Parallel procedures, rather than sequential procedures should be developed to implement a CAD/CAM system. The addressed recommendations can allow for the development of a successful and most importantly, a cost-effective system.

A core requirement is the establishment of feedback loops in which each stage communicates with all other stages. These cycles permit the improvement of the whole system and especially the maintenance of focussing on objectives. (See fig. 3)

6.1 Basic considerations

In order to know what the system means, you must answer two questions:

What kind of system do we need?
How does this system work?

To know both answers, you must consider the issues addressed in the first part of this document and apply them to the specific processes you perform. This step gives you an overview of the way you must integrate your own system.

6.2 System definition

This is equivalent to creating the project's blueprint. You must establish stages for the development of the project, defining the short term objectives and projections for medium and long terms. Similarly, you must take into consideration the availability of financial resources .

The questions you must answer here are:

What are we going to do?, When are we going to do it?

6.3 Definition of requirements

A CAD/CAM system is composed of three basic sections:

i) Infra-structure
This consists of the physical resources: machinery, tools, auxiliary equipment, software, hardware, plant, etc.

ii) Human resources
This means not only the people but also their capabilities: knowledge, experience, specific skills, etc.

iii) Organization
This covers all those actions you must perform to give the system the facilities it needs to work successfully: management, quality, procedures, environment, accountabilities, leadership, etc.

You must define requirements for each section, according to the needs of your system, by answering the following questions:

What does our system need?
What are we going to get first?
When are we going to get the rest of the required items?

6.4 Establishment of financial resources

At this point, you must answer the following questions:

STRATEGY FOR IMPLEMENTATION

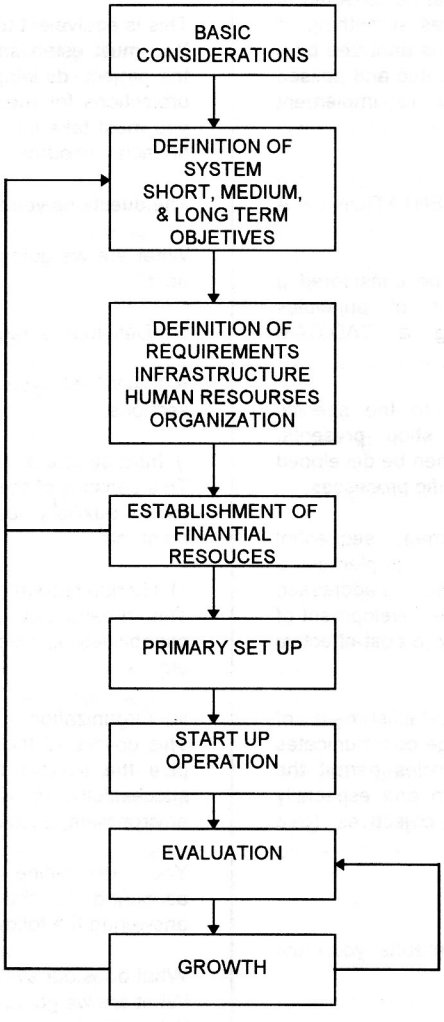


Figure 3 Implementation Strategy

What are the available financial resources?

How are we going to use them?

Both answers give you a base to check, and modify if necessary, the last two steps.

6.5 Primary setup

Once you have defined the system and its requirements, according to the financial resources, you are able to begin the implementation stage.

Here, you must decide which CAD/CAM system you are going to buy.

Of course, this a critical step, because you are obligated to find the best balance between the money you spend and your needs. The key for this step is:

Which is the system we must acquire?

At this point, it could be necessary to modify the whole plan and adapt it to resources and/or to requirements.

6.6 Start-up

Once you have installed your system's first stage, the only thing you need to do is "push the button",...but it's not that easy.

You must create a "start-up procedure" that lets you have feedback from the very beginning of your project. You need to develop the "operational tactics" that are going to characterize your system.

The key is:

What are our operation procedures?

6.7 Evaluation

Once you have started operations, you must setup an evaluation program that tells you how the system is going. The results of this program give you the base for improving your procedures.

CAD/CAM systems must be evaluated continuously and all members of the team must participate in this evaluation.

The most important concept here is to keep the objectives in focus and maintain the balance of resources.

6.8 Growth

System evolution and growth is a constant loop that involves the whole process. You must go through all stages, adapting them to the changes that have occurred to the system, each time an evaluation indicates another level of growth.

7. ACKNOWLEDGMENTS

The AID/CINDE Training Program participants gratefully acknowledge the contributions to learning about CNC technology of:

AID/CINDE office.
Georgetown University
Broome Community College
Wabash Valley College.

A special acknowledgment to the people of Universal Instruments Co., represented by Paul Hudec and the Fab's Center personnel.

By sharing their experience, they gave us the opportunity of improve our knowledge.

8. REFERENCES

1- Moll, Adrian. Shop of the 90½s The Implementation of a CAD/CAM System for Small Machine Shops. Estados Unidos, National Institute of Standadrs and Technology, 1992.

2- Stark, John. Managing CAD/CAM, Estados Unidos, I ed., MacGraw Hill, 1988.

3- Watkins, Carl et al. The Next Step, Computer Applications for the Shop. Modern Machine Shop, Vol. 66 Número 11a, abril 1994.