1.0 INTRODUCTION

This paper deals with computers use in factory management. GRAI laboratory research is directed towards a global approach of the problem previously called: "Piloting of manufacturing unit". Recently, the term "Guiding" has been preferred to "Piloting" and we use it now.

This text presents a proposition to design new computerized structure in order to guide the manufacturing system towards its goal in the same way a general system is guided.

Our approach is based on a hierarchical structure (conceptual model GRAI). Guiding is split up among the various decision levels of the hierarchical structure. Therefore we use a guiding structure into which we introduce some kind of "intelligence". The various functions of this structure are the following: scheduling, simulation, acquisition of factory data, feedback.

We first define the guiding concept for manufacturing systems. We show that manufacturing systems need two basic functions to be guided: scheduling and simulation.

Then we propose a structure for a computerized guiding system. We choose the example of a manufacturing system decomposed into units. This example is being implemented on GRAI's computer (VAX 780) by means of two complementary languages PROLOG and PASCAL.

Finally we show the importance of an artificial intelligence approach. All the guiding structure functions do not need artificial intelligence techniques to be performed but all of them are based on artificial intelligence concepts.

2.0 GUIDING CONCEPT FOR MANUFACTURING SYSTEMS

Guiding a general system consists in monitoring its running and driving each part of it towards its objectives.

Manufacturing systems belong to complex systems. In order to achieve its objectives this complex system need to be decomposed. For each sub-system we must define a sub-objective connected with the main goal of the system.

For this decomposition we use the GRAI model (fig.1) [DOU.84-2] for the following reasons:

- the decomposition criteria are directly connected with the decisions taken at each level of the system,
- the coherence of all decision centers is checked by the model,
- the Decision Frame concept allows to decentralize decision making.

The guiding concept can be used for every decision level or function in a manufacturing system (fig.2). Guiding a purchasing system is as significant as guiding a workshop. But in this paper we focus the guiding concept on workshop systems.

We first define the general concepts of system and system guiding. Then we precise these concepts for manufacturing systems. Finally we discuss about two basic functions for guiding a manufacturing system: scheduling and simulation.

2.1 Concept Of System And System Guiding

According to the previous work of [MEL.72], [MES.70], [DOU.84-2], we give the following definition for a general system:

"A system is a set of organized elements which operate with a common goal. These elements are linked by relations whose identification and formalization give the system structure."

A system can also be caracterized the set of transformations allowing to formalize the output elements of the system from the input elements.

Our study is concerned by systems whose complexity implies their decomposition into sub-systems. This decomposition implies the definition of:

- a sub-objective for each sub-system,
- a structure stating the relations between all the sub-systems.

As it was upper said, guiding a system means driving it towards its goal. So in order to do such a thing, four activities must be defined:

1. to calculate a reference: this activity determines paths allowing the system to reach its goal. For a system described as a structure of sub-systems, the reference is defined as a set of sub-references. One for each sub-system.
2. to command the elements (or sub-systems): this activity is concerned by sending orders to elements in order to guide the system towards its goal. It is done according to the reference.

3. to follow the elements state: this activity has to measure a set of significative variables periodically.

4. to react (or feed-back): this activity compares the true state of the system with the reference. It may decide:
   — to adjust orders for system elements to assess the gap between this state and the path defined by the reference.
   — to ask for a new reference calculus more adapted at the new state of the system.

2.2 A Manufacturing Guiding System

A manufacturing system can be described as a complex and hierarchical system whose elements are units, products, resources (machines, men, tools, informations, ...) and time.

In this paper, we choose a manufacturing system consisting in n units. We define two guiding levels: the system level and the unit level (fig.3).

The system level is concerned by giving sub-objectives to each unit. It controls the flow of products between units to reach the global reference calculated for the system.

The unit level is concerned by driving resources and products inside a unit.

Both guiding levels can be described by means of the four activities already defined:

1. the reference is a planning. At the system level, the planning gives for each unit the dates and quantities of each product. For unit level, the planning is more detailed and gives the same informations for each machine.

2. the elements concerned by the command activity are units for system level and machines for unit level.

3. the variables measured by the follow-up activity are related to the global state of the units for system level and to the state of machines for unit level.

4. the feedback activity may decide:
   — to modify a little the reference planning in order to reach the goal defined by the upper level,
   — to make a new planning because perturbations are too important.

The design of a guiding system needs to use two basic functions which we are going to define now.

2.3 Basic Functions For Guiding: Scheduling And Simulation

These two functions are specific of physical manufacturing system guiding.

First, scheduling techniques are used to obtain the reference planning. They are also used to adjust or modify the same planning.

Secondly, simulation techniques are used to measure future states of the guided system. They are a decision-aid to decide whether a reference planning must be modified or not.

3.0 PROPOSITION FOR A GUIDING STRUCTURE

As we upper saw, the physical Manufacturing System can be decomposed into two levels:

1. the System level (which gives objectives for each Unit),
2. the Unit level (which is concerned in reaching the objectives defined by the System level).

In the following, we will present the Guiding Module of each level according to figure 4. We are now implementing this module on the GRAI's computer.

3.1 The Unit Level

At this level, a Guiding Module is attached to each Unit.

The inputs of a Unit Guiding Module are collected in a list of orders composed of:

1. the products names to be processed in this Unit,
2. the entry and output dates for each product.

The main purpose of the Guiding System is then to process these products in time according to the other constraints.

This is done by means of four modules:

1. the Calculus reference Module which chooses a strategy for the Scheduling Research and gives then a detailed Scheduling according to this strategy.
   At this level, A.I. techniques can be useful in order to obtain the best strategy according to the user's needs.
2. the Following-up Module which collects data concerning this Unit and which receives Alarms in case of breakdown.
   This has to be done regularly, and rather