A SYSTEMIC APPROACH TO CONSIDER COMPLEXITY IN SAWMILL MODELING[1]

Robert Beauregard

Graduate Student

Michel Beaudoin

Professor
Département des Sciences du Bois

Daoud Ait-Kadi

Associate Professor

Département de Génie Mécanique
Université Laval
Québec, Canada, G1K 7P4

and

Jean-Pierre Mongeau

Research Scientist
Forintek Canada Corp.
Université Laval
Québec, Canada, G1K 7P4

ABSTRACT

The lumber industry is challenged to operate more efficiently. Sawmill systems use much equipment with various technologies and their management methods are very much influenced by size of operation, employee skills, hierarchy levels, and the high volatility of softwood lumber commodity markets. Because of interactions between the different manufacturing system components, its management becomes a complex matter. It is therefore difficult to assess the effect of given perturbations or improvements on the overall system.

This study proposes a modeling approach based on the concept of system that provides a comprehensive view for modeling and analyzing sawmill systems. Adaptations of existing formalisms to represent operating, information, and decision sub-systems are put forward, while assembling these three sub-systems in an overall model gives a new vision of the sawmill and a powerful tool for systems integration. This modeling approach could be used for diagnostic as well as for sawmill improvement. Various examples are provided on the application of this approach.

Keywords: Systemic approach, sawmill operation, diagnostic, integration.

INTRODUCTION

Today's sawmill industry is confronted with important challenges. First, it must face the competition of new products on building materials markets. Steel, aluminum, and concrete share a growing part of these markets, while polymers and composite materials are more and more present in weather board, doors or window overlays. Second, the raw material cost, essentially wood cost, is regularly rising because of scarcity due to high levels of har-

vesting and environmental issues raised in all Western countries.

Besides these market and raw material constraints, sawmill manufacturing systems are intrinsically complex entities. Wood is a highly variable biological material. Out of every stem or log, numerous sawing patterns, yielding a large amount of possible product mix, can be considered. The sawyer has to get the maximum value out of every single log. Furthermore, when a particular product mix is manufactured from a given stock of raw material, using a particular technology and organization, the lumber must be sold on a highly volatile commodity market. Important stocks of semi-finished lumber are often built up in order to speculate on the market. The customers are given the opportunity to buy dry or green and planed or rough lumber. Hence when orders are received, the sawmill has yet to carry out some finishing operations (drying, remanufacturing, planing, packaging). In addition to these characteristics specific to the sawmill industry, the usual functions of machine operation and maintenance, purchases and sales logistics, human resource management and planning must also be considered in order to draw a complete picture of the complexity of such a manufacturing system. The large number of processors, transactions, and data handling makes it difficult for the decision-makers to consider all aspects of the puzzle. Often, the actions taken do not give the expected results.

Using operations research approaches, several tools were developed to help decision-makers with specific aspects of the general problem of sawmill operation. Indeed, tools are available for sawmill layout (Carino and Bowyer 1981; Adams 1984; Tochigi et al. 1988), log allocation (Maness and Adams 1991), process modeling, simulation, and optimization (Hallock and Lewis 1971; Wagner 1982; Zeng and Funck 1990; Mongeau and Grondin 1992), and for inventory management (Holemo 1971). Because they lack a general view of the system, these tools neglect the interactions between the different components and often lead to very costly actions (instal-

lation of new equipment, acquisition of sophisticated software), whose contribution to the overall performance may be negligible or even negative.

This need for a comprehensive vision and more integration instigated the development of a systemic approach to model sawmills in their whole complexity. Recent developments in system sciences (Baudin 1990; Mantha et al. 1988; Le Moigne 1990) are contributing to the development of representation tools in order to model manufacturing systems as a whole.

Le Moigne (1990) defines the general system as an entity situated in an active environment, capable of transforming an input into an output on a regular basis and animated by a project or by objectives. In order to pursue its objectives in its environment, it develops structures and transforms itself over time. A manufacturing system can decide to change its objectives and redesign itself accordingly. This ability is called the genetic capacity of the system.

Manufacturing systems are often divided into three sub-systems. First the operating system (OS) is the sub-system whereby materials are processed. In the case of sawmills, the input—stems or logs—is physically transformed into an output (rough lumber), and eventually into dried, dressed-size planed lumber, sawdust, wood chips, and bark. The second sub-system, the decision system (DS), is the one where the objectives are determined, where the products and the system itself are designed, and where the coordination and the control are performed on a day-to-day basis. The third sub-system is the information system (IS) where information on the environment, on the OS and from the DS is gathered, stocked, and processed to make the link between the decisions, the operations, and the environment.

The objective of this paper is to present a systemic methodology for modeling existing sawmills. In the first section, the general approach of systemic modeling is presented. The second, third, and fourth sections present the formalisms and the diagrams used to represent the operating, information and decision sub-

systems, respectively. The last section explains how these diagrams are put together in order to create an integrated representation of a sawmill system. Finally, the paper concludes on how this original modeling approach can be useful for the diagnostic and the conception of more integrated and efficient sawmills.

A METHODOLOGY FOR SYSTEMIC MODELING

The systemic approach considers it more suitable to describe an entity by its functions and/or transformations rather than by its structures. Hence, from this perspective, what is represented is either processor or processed. A processor can be characterized by its position in a three-dimensional field of time, space, and form. According to this, we designate time processors as processors specialized in time transfer, space processors in spacial transfer, and form processors in physical transformation. Table 1 presents some examples of these processors for a sawmill manufacturing system.

However, in order to use the systemic approach to model sawmills, we need more than a concept, we need tools and procedures. Several formalisms have been developed to draw functional representations of systems and subsystems. The next sections present those used in this study. From the work of Baudin (1990) on manufacturing systems analysis, we took the symbolism to represent the operating system. The formalism for information system modeling was taken from the work of Mantha et al. (1988) on the development of computer integrated organizational systems. Our choice was guided by the capacity of the different formalisms and modeling approaches to work well with the concepts of processors of form, time, and space. We did not find any established standard formalism to represent the processors of the decision system. The diagrams presented here on the DS were inspired by the work of Le Moigne (1990) on general systems theory. These existing formalisms have been adapted and completed in an overall modeling

TABLE 1. *Examples of processor types used in the design of a sawmill system.*

Processor types	Operating system	Information system
Time processor	Stock of logs	Data base
	Bin of accumulation	Clients' files
		Production records
	Stock of sawnwood	Account files
Space processor	Lift, truck	Modem
	Transfer chain	Phone line
	Belt conveyor	
Form processor	Slasher	Arithmetic and logic unit
	Debarker	
	Headrig	Break-even point function
	Edger	
	Trimmer	Summary of production
	Kiln	
	Planer	

approach for sawmills as manufacturing systems.

FORMALISM TO REPRESENT THE OPERATING SYSTEM

The standard symbols of the American Society of Mechanical Engineers, according to Baudin (1990), are appropriate for the description or the design of operating systems. This formalism allows the functional description of the transformation of an input into an output, through modeling the material flow network (MFN) of the operating system. An advantage of this formalism is that it is the one traditionally used for graphic coding of specifications and industrial engineering studies.

Figure 1 presents the symbols used for the material flow network modeling. The symbols used to depict external entities, operations, inspections, stocks, transports, and material flows are presented and accompanied by the rules suggested to design MFN.

Baudin (1990) extended the approach to hierarchical modeling. In this concept, a context diagram is drawn and its components may be exploded into more detailed diagrams. This process of exploding the general into the particular may be continued as long as it adds sense.

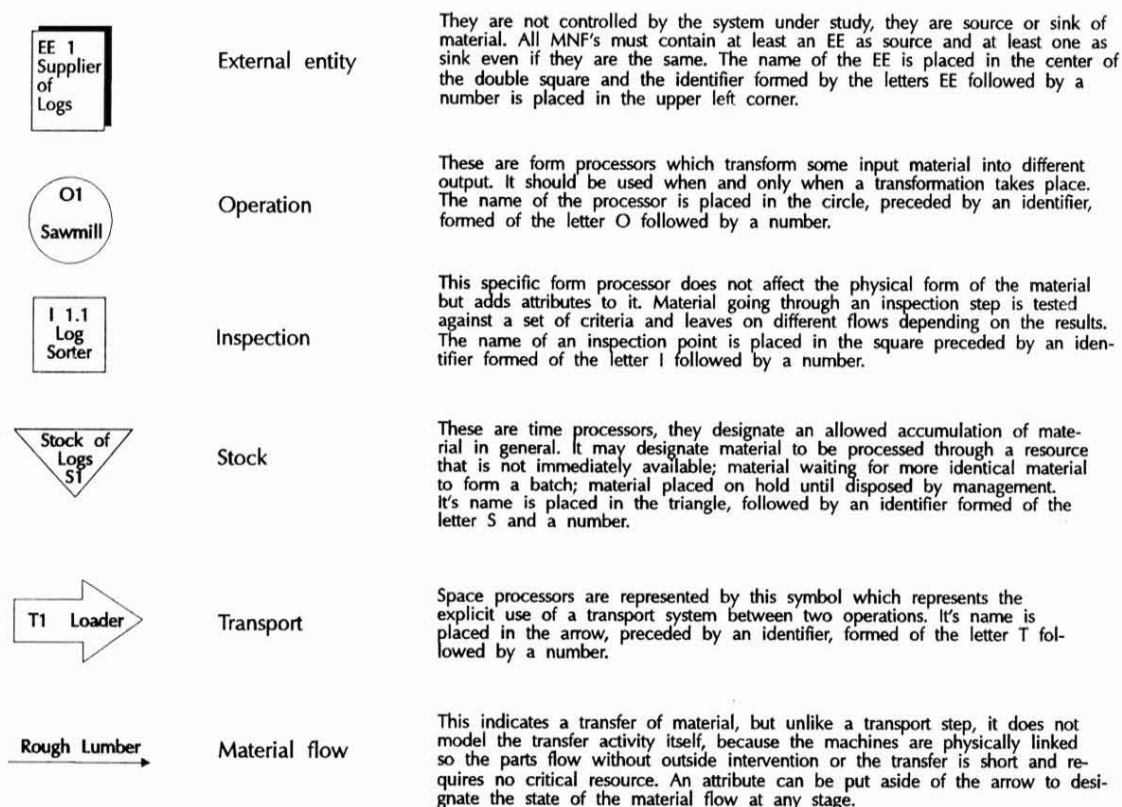|		
EE 1 Supplier of Logs	External entity	They are not controlled by the system under study, they are source or sink of material. All MNF's must contain at least an EE as source and at least one as sink even if they are the same. The name of the EE is placed in the center of the double square and the identifier formed by the letters EE followed by a number is placed in the upper left corner.
O1 Sawmill	Operation	These are form processors which transform some input material into different output. It should be used when and only when a transformation takes place. The name of the processor is placed in the circle, preceded by an identifier, formed of the letter O followed by a number.
I 1.1 Log Sorter	Inspection	This specific form processor does not affect the physical form of the material but adds attributes to it. Material going through an inspection step is tested against a set of criteria and leaves on different flows depending on the results. The name of an inspection point is placed in the square preceded by an identifier formed of the letter I followed by a number.
Stock of Logs S1	Stock	These are time processors, they designate an allowed accumulation of material in general. It may designate material to be processed through a resource that is not immediately available; material waiting for more identical material to form a batch; material placed on hold until disposed by management. It's name is placed in the triangle, followed by an identifier formed of the letter S and a number.
T1 Loader	Transport	Space processors are represented by this symbol which represents the explicit use of a transport system between two operations. It's name is placed in the arrow, preceded by an identifier, formed of the letter T followed by a number.
Rough Lumber	Material flow	This indicates a transfer of material, but unlike a transport step, it does not model the transfer activity itself, because the machines are physically linked so the parts flow without outside intervention or the transfer is short and requires no critical resource. An attribute can be put aside of the arrow to designate the state of the material flow at any stage.

FIG. 1.   Pictograms used in the material flow networks (Adapted from Baudin 1990).

A fictive sawmill was created to illustrate how to use the systemic approach in order to model sawmills. Figure 2 illustrates the context diagram of a material flow network representing the OS of this fictive sawmill. The boundaries of the system are defined by the external entities. The first external entity (EE 1), suppliers of logs, is the only source of material in this representation. Its being the only source of the system indicates the importance that should be placed upon it. The other external entities are called the sinks: lumber (EE 2), bark (EE 3), wood chips (EE 4), and sawdust (EE 5) customers. The lumber customer entity (EE 2), being situated at the end of the production process mainstream, suggests that it is the main sink of the system. The other ones (EE 3, 4, and 5), by their situation as by-product customers, are given less attention.

This context diagram also indicates that logs are stocked at the entrance of the system (S 1).

Afterward, they are brought (T 1) into the sawmill itself (O 1). At the output of the sawmill, the flows of material constitute stocks of rough lumber (S 2), bark (S 4), wood chips (S 5), and sawdust (S 6). The rough lumber is then brought into a dryer (O 2), dried, and stocked as dry lumber (S 3). At the end of the process, it goes through a finishing center (O 3). The fact that no intermediate stock exists between O 3 and EE 2 suggests that finishing is performed only on demand, never on stock.

At this level, the system may appear rather linear and simplistic. The processors of this diagram can further be exploded into more detailed material flow networks. Figure 3 illustrates the explosion of the sawmill itself (O 1). Every object in this sub-system is numbered using decimal numbers—the unity of the number being the one of the original processor in the context diagram and the decimal, the identifier of the sub-processor. The objects
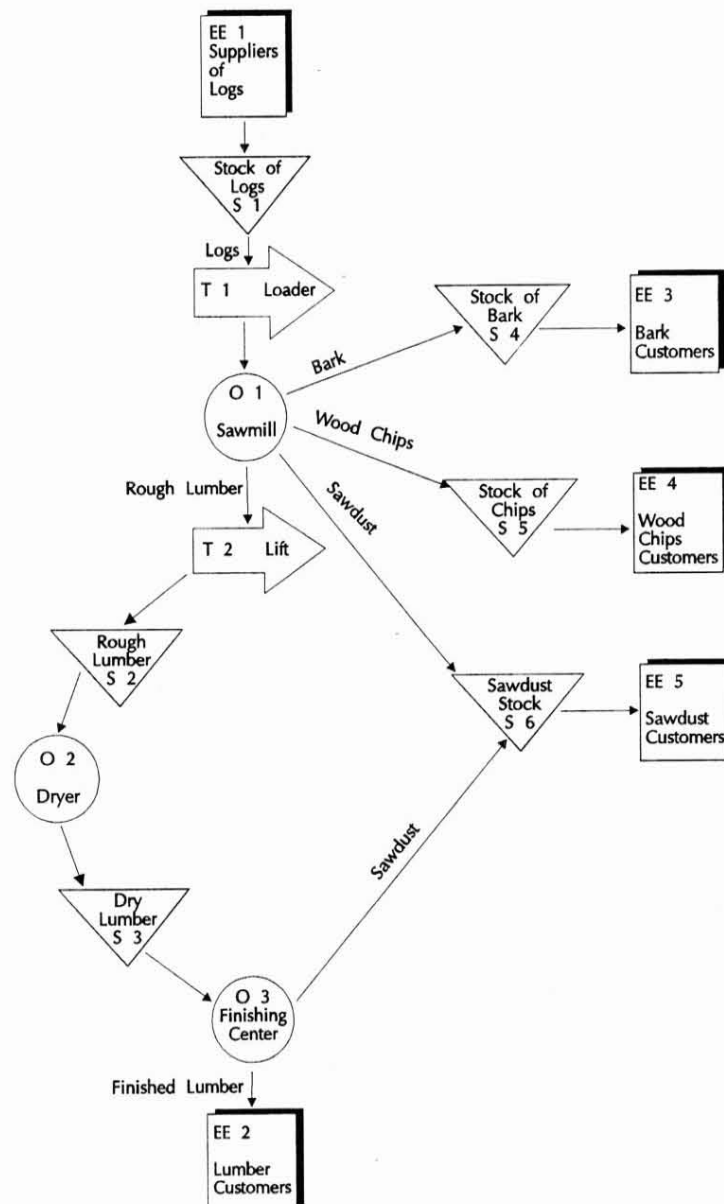
FIG. 2. Material flow network of a sawmill operation: the context diagram.

without decimal identifiers constitute the boundaries of the sub-system.

In our example, when logs are brought into the mill, they are stocked in a soaking bin (S 1.1). From there, they pass through a scanner (I 1.1), which separates them into two log size classes. This is the beginning of two production lines. The small log line begins with a buffer (S 1.2) where the logs are accumulated in front of a small debarker (O 1.1). The bark is brought out of the sub-system to the stock of bark (S 4) situated in the context diagram. Debarked logs are processed through a chipper edger headrig (O 1.2). This machine produces wood chips routed to S 5 and cants, which go to a multiple saw edger (O 1.3). This edger pro-
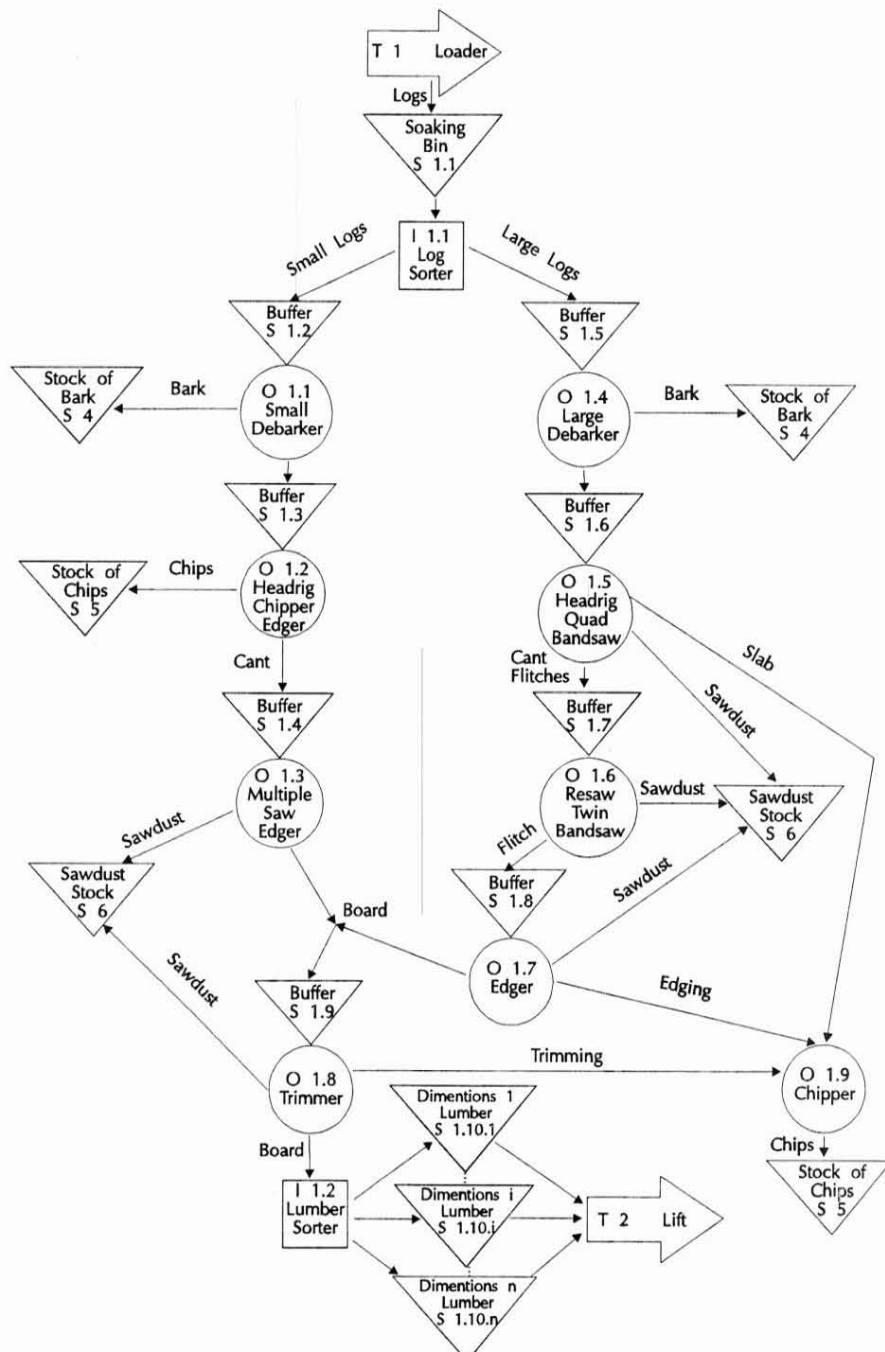
FIG. 3. Material flow network: explosion of the sawmill processor.

duces sawdust as a by-product (S 6) and boards sent to a buffer (S 1.9) in front of the trimmer (O 1.8). The trimmer is the station where the two production lines merge.

The second line begins with a buffer of large logs (S 1.5) feeding a debarker (O 1.4). De-barked logs are sent to a quad bandsaw headrig (O 1.5). This headsaw produces slabs, routed

to a chipper (O 1.9), sawdust (to S 6), cants, and flitches. The cants are routed to a resaw (O 1.6). This resaw also produces flitches, which go to an edger (O 1.7). From this edger, sawdust (to S 6), edgings (to the chipper O 1.9), and boards are produced. The boards join the ones from the first line, in front of the trimmer (O 1.8). The output of the trimmer is trimmed boards, which are processed through an automatic lumber sorter (I 1.2). Sorted boards are stocked by categories of sections and lengths in individual bins. This is the end of the sawmill sub-system (O 1). Boards are transported by a forklift (T 2), which is part of the context diagram.

Exploding processes downward can continue as long as more detailed representation is needed, while avoiding excessively busy diagrams. These diagrams can be further explained using a flow process chart. Figure 4 contains an example of a flow process chart of the fictive sawmill represented in Fig. 3. The first column of the table describes the processor under study, the second refers to the position of the processor in the material flow network. The next three columns give summary information on the distance covered by the material, how many units are handled at the time, and how much time it takes to perform this process. In the case of stocks, the quantity column indicates the accumulating capacity and its average level of occupation. The rest of the table is dedicated to process diagnosis. The analyst may use these columns in a "dot and check" manner. These simple questions facilitate the search for what is going wrong in the OS. In this fictive example (Fig. 4), the flow process chart indicates a problem of undercapacity at the debarker. Because of the relatively low cost of this piece of equipment, the debarker should not be the bottleneck of a sawmill. Such a problem should be quickly corrected. Other problems are also identified in this chart. For example, it is stated that the loader operator is often idle. Mud and bark are accumulating in the soaking bin and impeding the proper utilization of the bin. It is also established that there is a problem of qual-

ity at the multiple saw edger. All these problems can be recorded in this chart.

These are only examples, but they show how this modeling tool can be useful in diagnosing an existing OS or in designing an improved one. Another main advantage of this representation mode is its compatibility with the formalisms selected to model functional data flows in the information system. This is the object of the next section.

FORMALISM TO REPRESENT THE INFORMATION SYSTEM

The problem of representing data flow is conceptually very similar to the one of representing material flow. Functions performed by any processor in the operating system may generate information destined for the information system. For these reasons, as well as for coherence in our representations, we chose to picture the data flow diagramming (DFD) with a formalism highly similar to the one chosen to represent the material flow networks. This tool is known as structured system analysis, and a detailed presentation can be found in Mantha et al. (1988). Gane and Sarson (1979) defined the general approach of DFD as this:

> It shows the sources and destinations of data (and so by implication the boundaries of the information system), identifies and names the logical functions, identifies and names the groups of data elements that connect one function to another, and identifies the data stores which they access. Each data flow is analyzed, its structures and the definitions of its component data elements stored in the data dictionary. Each logical function may be broken down into a more detailed DFD.

This last process is similar to the one described in the preceding section as hierarchical diagramming.

In order to build these DFDs, it is necessary to collect at least one specimen of all data circulating in the organization. These may take any form: written information, manuscript notes, computer data, etc. In order to complete these sources of data, it is necessary to talk with the people involved in each data production and circulation. For all primary data, the

Fictive Sawmill Co

FLOW PROCESS CHART

No. 95

Page 1 of 3

JOB __Sawmill processor itself__

☐ MAN OR ☒ MATERIAL __Production of rough lumber from logs__

CHART BEGINS __The loader brings the logs to the mill__

CHART ENDS __At the end of the mill, after the lumber sorter__

RECHARTED BY __R.B.__   DATE __05/02/92__

SUMMARY

	PRESENT		PROPOSED		DIFFERENCE	
	NO	TIME	NO	TIME	NO	TIME
○ OPERATIONS						
⇧ TRANSPORTATIONS						
☐ INSPECTIONS						
▽ STORAGES						
DISTANCES TRAVELLED (Meter)						

DETAILS OF (Present) METHOD	OPERATION	TRANSPORT	INSPECTION	STORAGE	DISTANCE IN METER	QUANTITY	TIME IN SEC.	WHAT?	WHERE?	WHEN?	WHO?	HOW?	NOTES	ELIMINATE	COMBINE	SEQUE.	PLACE	PERSON	IMPROVE
								WHY?						ACTION		CHANGE			
Logs are transported from the yard to the soaking bin, using a loader	○	⇧	☐	▷	80	12	180	·	·	X	·	·	Operator of the loader is often idle					X	
Logs are soaked to be washed. This bin must contain enough logs to feed the mill with regularity	○	⇧	☐	▷	9	45		X	·	·	·	·	Accumulation of mud and bark in the bin	X					
Logs are scanned to sort large and small ones	○	⇧	☐	▷		1	9	·	·	·	·	·							
Beginning of the first production line	○	⇧	☐	▷															
Logs are accumulated in a transverse bin in front of the small debarker	○	⇧	☐	▷		15/15		·	·	·	·	·							
The small logs is debarked	○	⇧	☐	▷		1	5	·	·	X	·	·	The debarker is a bottleneck. It's capacity should be increased						X
Debarked logs are accumulated in front of the Chipper edger	○	⇧	☐	▷		15/1		·	·	·	·	·							
The small log is sawn by the chipper edger	○	⇧	☐	▷		1	4	·	·	X	·	·	This heading is often idle						
The edged cants are accumulated in a transverse bin, before the multiple saw edger	○	⇧	☐	▷		10/2		·	·	·	·	·							
The cants are resawn into boards by the multiple saw edger	○	⇧	☐	▷		1	6	X	·	·	·	·	The saws of this machine are misadjusted, problem of quality						X
At this stage, the second production line joins the first one	○	⇧	☐	▷															

Fig. 4. Example of flow process chart (adapted from Salvendy 1982).

EE 1 Suppliers of Logs	*External Entity*	Source or sink of information, corresponds to the EE in the OS. All DFD's must contain at least an EE as source and at least one as sink even if they are the same. The identifier of these entities is the same in the IS as in the OS.
5 Accounting	Process box	This symbol represent processing and communication functions performed by the processing entities (resources of the organizational system). The identifier is found in the upper part, the middle part contains the name of the process while the lower section may contain the resources used to transform the input into output.
←——→	Data Flow	The directed arcs are used to represent the circulation of data elements between a process and a data store, an external entity or another process. If necessary, a two-way flow may be defined. It may be identified by a name and it contains a list of data elements.
D9 Transactions	Data Store	The data stores are "time" processors used to memorize informations. They are identified by the letter D followed by a number and described by a name. Informations contained in data stores can be derived from data flows entering them. The informations contained in data flows are given in the data dictionary.

FIG. 5. Pictograms used in the data flow diagrams (adapted from Mantha et al. 1988).

source, the sink, the form, the content, and the way they are used must be established.

In the DFD formalism, the processing and circulation of information are represented by external entities, data processors, data stores, and data flows. The symbol conventions and the rules suggested in the design of a DFD are described in Fig. 5.

The context diagram of the data flow diagram of our fictive sawmill is presented in Fig. 6. There are two purchasing processors. Processor 1 records logs purchased from the suppliers of logs (EE 1), and processor 2 records parts and general furniture purchased from general suppliers (EE 6) for the mill operation. To accomplish these tasks, the processors access data stores specialized in the listing of the supplier attributes (D 9 and D 10), and they store the information on purchased goods in data stores (D 1). A processor is also specialized in handling information on human resource management (4). It records information on the number of hours worked by the employees (EE 7) and keeps track of the salaries owed and paid, using a data store on employees

(D 3). Processor 3 records all relevant information on the production itself: log consumption, lumber production by classes, and also the quantities of by-products outputted at every shift. These data are stored in (D 2), the production data store, which may be accessed by processor 7, the one that records data on the sales of lumber and by-products to the different customers (EE 2, 3, 4, 5). Details on the customers are accessible through data store D 7, while the orders are stored in D 6. The information on all transactions is transferred to the accounting processor (5). This processor stocks the information in the transactions data store (D 8) and files all this information in the ledger. Accounting data are transferred to the budget follow-up processor (6), which can access information on the budget (D 4) and on the production (D 2), and can make reports on the situation of the firm. It stores unitary costs and revenues data in D 5. Any part of the context diagram could be further exploded. This would be done in a similar way as was done in OS modeling.

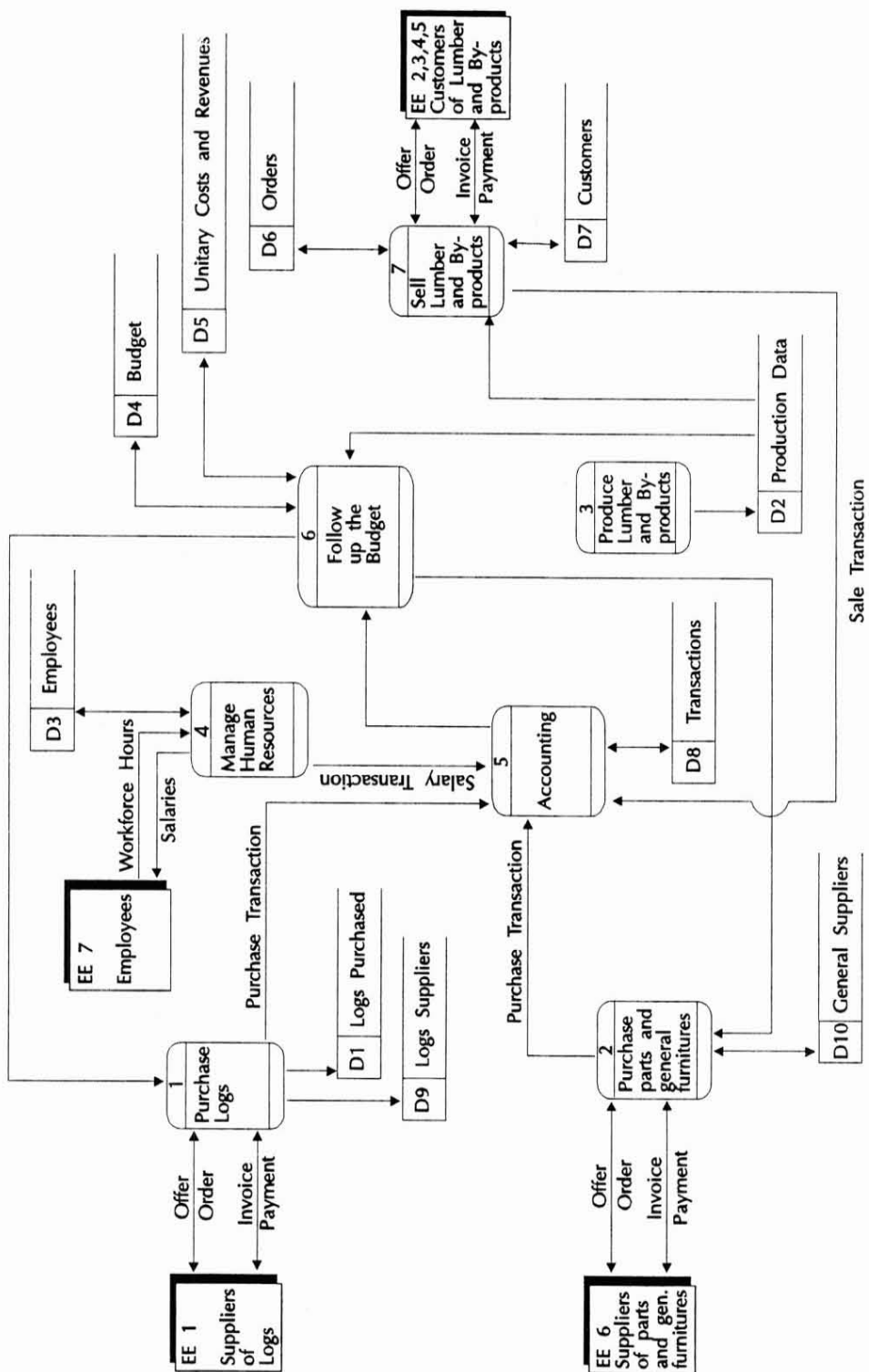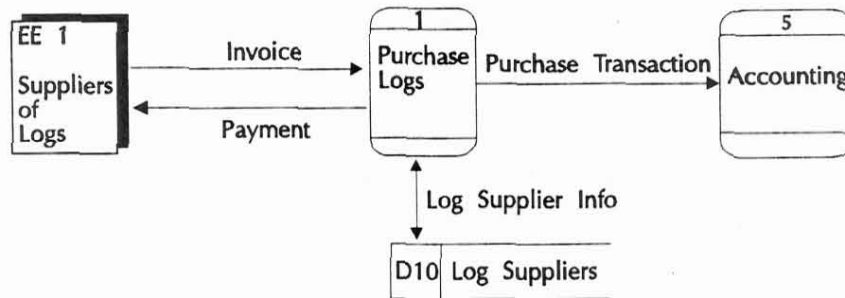A data flow is identified by a name and con-

FIG. 6.   Data flow diagram of a sawmill operation: the context diagram.

where

Log Supplier Info	Payment	Invoice	Purchase Transaction

LOG SUPPLIER
  number
  name
  address
  log weight factor
  unit price
	PAYMENT
	  number
	  date
	  LOG SUPPLIER
	    number
	    name
	    address
	    log weight factor
	    unit price
	  weight of logs
	  price
	  tax
	  total paid
		INVOICE
		  number
		  date
		  LOG SUPPLIER
		    number
		    name
		    address
		    log weight factor
		    unit price
		  weight of logs delivered
		  price
		  tax
		  total due
		  due date
			PAYMENT
			  number
			  date
			  LOG SUPPLIER
			    number
			    name
			    address
			    log weight factor
			    unit price
			  weight of logs
			  price
			  tax
			  total paid

FIG. 7. Example of data structure.

tains a list of data elements. These data elements can be structured. A data structure is made up of a number of data elements, which *may themselves be structures* (Mantha et al. 1988). Figure 7 shows an example of a data structure. The total set of data structures and data flows constitutes the data dictionary. Data dictionaries complete the documentation of the system.

This approach of diagramming can be used to show deficiencies in the information system. For example, in Fig. 6, it can be seen that no data store exists, in relation to processor 2, on general furniture and repair parts purchased. Redundancies or deficiencies in the logic of data circulation can also be detected. Redesigning an improved IS and implementing it in the framework of, for example, an integrated data base management system (DBMS) are all capabilities of such a formalism.

The framework presented in the previous sections on OS and IS modeling is not yet a fully open system, meaning that it is rather static over time. It can interact with its environment as long as this environment does not change too fast. These diagrams do not include the genetic capacity of evolution, which is constitutive in the definition of an open system (Le Moigne 1990). This aspect will be discussed in the next section.

REPRESENTATION OF THE DECISION SYSTEM

We have not found any established standard formalism to represent the decision system. The representations introduced hereafter are inspired by Le Moigne (1990). In order to build the model of the DS, the hierarchical structure of the organization should first be studied. Second, it is necessary to proceed with interviews
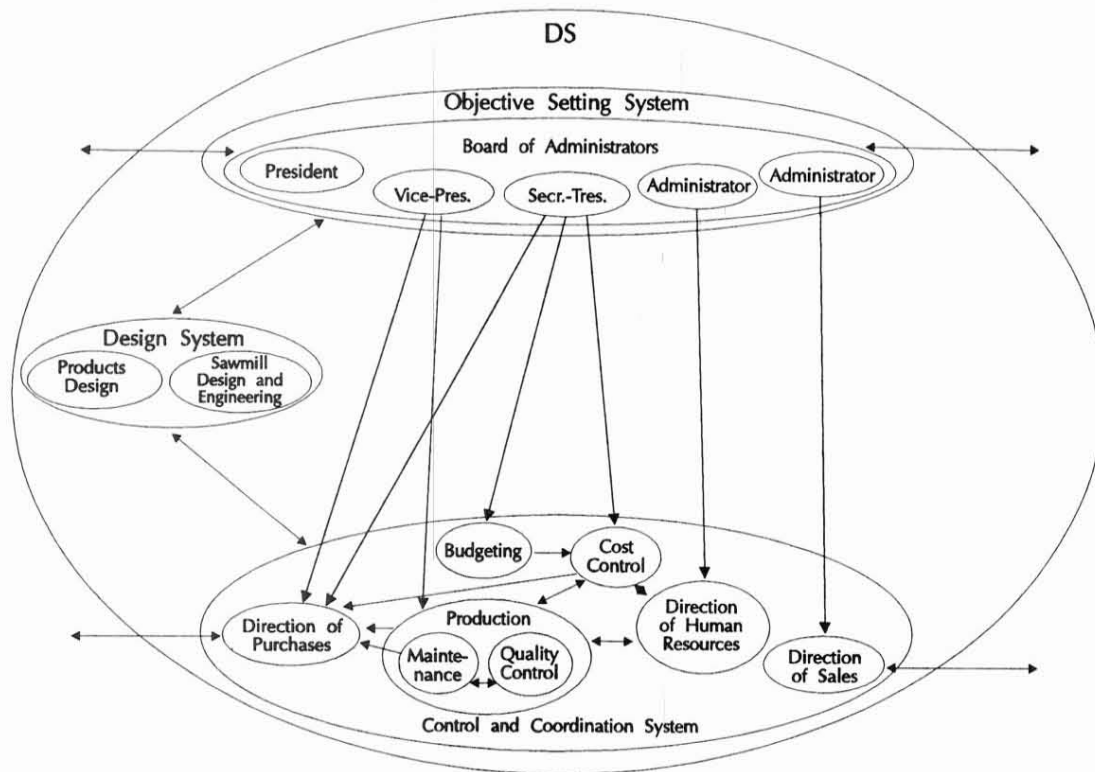
FIG. 8.   Representation of the decision system.

from top to bottom, or vice versa, of the social structure in order to detect who really accomplishes each function. Very often there is a substantial difference between the official structure and the true network of the DS. Such interviews will confront the different subjective appreciations of the DS, and a more comprehensive point of view might emerge.

The diagram presented in Fig. 8 introduces the three levels constituting the DS. The lower level is the control and coordination system (CCS), where functions like production, maintenance and quality control, direction of human resources, purchases, sales, budgeting, cost control are performed. The second level is the design system (DsgnS), where the sawmill system is designed or redesigned according to the evolution of the environment. The last subsystem of the DS shown in Fig. 8 is the objective setting system (OSS). This is the in-

stance where the purpose of the whole system is defined and formalized. It is triggered by important changes in the environment and by the volitions of the stakeholders of the system.

As mentioned earlier, the role of the IS is to gather and organize information in such a manner that decisions can be taken rapidly and necessary instructions sent back to the OS. In the approach of integration, the three sub-systems of the DS need different technologies of information. At the CCS level, the question that must be answered is: Is the operation of the mill as effective as possible? The important feature is that the information on all relevant operations be correctly and rapidly captured and handled logically in the IS so that this level of decision can perform properly. It is the level where the integration will usually first occur because of the rather repetitive nature of the operations. The type of problems detected at

this level are of different kinds. For example, if different persons or directions are in the position to make decisions on the same matter at the same hierarchical level, serious problems of coordination and control can occur. For instance, if the person responsible for maintenance, say the vice-president, orders a particular repair part but the person responsible for finances, like the secretary-treasurer, decides to purchase a similar part of lesser quality because of a price difference, and if there is no arbitration, conflict may occur. This is a typical example of overlapping between two directions. Another possible conflicting situation may occur when there is no link between the sales and the production directions. The system may miss important opportunities. The sales instance is usually in the best position to be aware of the opportunities in the market place. Often, these opportunities are valid for only a short period of time and to capitalize on them, there must be very tight collaboration between the sales and the production functions. If the production direction thinks it is hard enough to keep the mill in control and that it would be too difficult to consider market constraints, the whole system may operate in a very sub-optimal state.

At the design level of the DS, tools that deserve conception, typically CADs, or simulation tools, are needed. These tools must be efficient in putting down graphically designed specifications and in answering the "what if" type of questions like: What would happen if the debarking capacity was doubled? These tasks are quite different from those performed by the control and coordination sub-system. For integration purposes, computer systems dealing with these two sub-systems should communicate and share some particulars like the same names and attributes to designate the same objects, products, or machines. Therefore the design sub-system should not be conceived without considering all aspects of the organization.

Finally, integrated tools developed in order to assist the functions of the third level of the DS, the OSS are very different from the other two. They must be able to process data in a way that ensures a comprehensive view of the operations, on a large time scale. At this level, it is important to count on the best objective information possible. In order to supply this information, tools must be custom designed to provide highly processed indexes of performance. Such tools can take the form of periodical reports, comprehensive information presentations on sales, production, costs, productivity, and profits. They can also take the form of a DSS giving access to overall indexes via a computer and providing more details on any particular topic when needed.

The issue of gathering information from the inside of the system is important, but success will often come from the administrator's ability to go beyond inside information and get relevant outside information from the environment of the system. At the OSS level the question of operating as efficiently as possible is as important as the question of manufacturing the right products at the right moment. The necessary information to answer this question can seldom be found inside the organization. So, it is probably impossible to define a DSS that could adequately perform the functions attached to objectives setting. This level must remain largely open. People who accomplish these tasks must be chosen for, or must rely on, their experience, intuition, and ethics. One example of this issue in the OSS is the possibility for leaders to detect and understand the benefits they can get from a major breakthrough in sawmilling technology and to implement it in the organization. This cannot be done only through exploiting the information inside the organization. Another example is the capacity for the direction of a sawmill to detect long-term trends in lumber trade. This capacity will often make the difference between sawmills that die, survive, or emerge as leaders in their field.

AN INTEGRATED REPRESENTATION OF SAWMILL SYSTEMS

A comprehensive view of the sawmill system can be obtained by gathering all the pre-

vious representations. In each section, the types of problems that could be detected in the OS, in the IS, or in the DS using the respective representation were pointed out. The final step of assembling all the parts in one general diagram is the most important one. When we drew a representation of the three sub-systems of our fictive sawmill, we were compelled to pay attention to the parts of the system. For example, in the OS, we mentioned that an undercapacity at the debarker could prevent us from taking full advantage of the capital invested in the rest of the mill. In the IS, we were made aware of some problems in the purchasing procedures. In the field of DS, at the control and coordination level, a missing link was considered between the production and sales directors. At the objective setting level, we stressed the importance of using the information from the outside of the system, in order to follow the trends in the environment. However, all these representations did not bring about a comprehensive view of the system.

Figure 9 presents the general diagram of the fictive sawmill previously developed. Using this overall view of the system, it should be easier to identify the points on which to put our effort, considering all the interactions between the different processors. For example, if we improve the actual debarking units, our production capacity in volume of lumber will increase. This would neither change our product mix, nor our flexibility, thus resulting in greater quantities of commodity stock for sale and possibly reducing the time sales persons have to prospect higher value-added markets or opportunities. In order to be able to sell these higher stocks of wood, they might be forced to concede discounts. The whole result of the operation could very well be reduced profits. An increase in production capacity should always be considered along with a revision of the commercial strategy.

In another example, if the president wants to solve the problem between the sales and production managers, he could consider getting rid of one of them because of his perception of personality conflict. However, if he fires the director of production, he may lose the confidence of all the production employees; and if he fires the director of sales, he may lose the very valuable perception of markets this manager had and in the long run, the two solutions may be losers.

Considering the model of his sawmill, the principal officer of the organization might decide that new objectives are necessary. A new strategy could be developed and used as a motivation tool. It could be decided, for example, that in order to face the more and more rapid changes in lumber trade and markets, the organization should develop more flexibility. This idea of getting more flexibility could then become the cornerstone of a new vision for the development of the sawmill. Instead of investing a lot of money in solving some problems detected during the model building process, the organization might decide to invest its efforts in pursuing more flexibility.

Every time a serious intervention is required in the sawmill, the general model should be used to look at all possible solutions and their consequences. The general model may help to assess how a solution to a particular problem could become an element of the implementation of the new strategy. The new question for the debarking problem would then become: What debarking system is needed to gain flexibility? The new question for the conflict at the direction of the mill becomes: Can the two directors share a common vision of the new strategy? How is it possible to convince them to work toward this new objective? The systemic approach is a useful tool to define objectives that can bring improvements at the highest level. It is also a graphic tool to be used to share and discuss visions on the system.

All these examples are from a fictive sawmill, but a case study using this approach has been carried out to evaluate and represent the operation of two different sawmills in the province of Québec. A working paper (Beauregard et al. 1993) presenting these case studies and testing the method in two different contexts is available. This contribution renews the toolbox for sawmill representation and diagnostic.
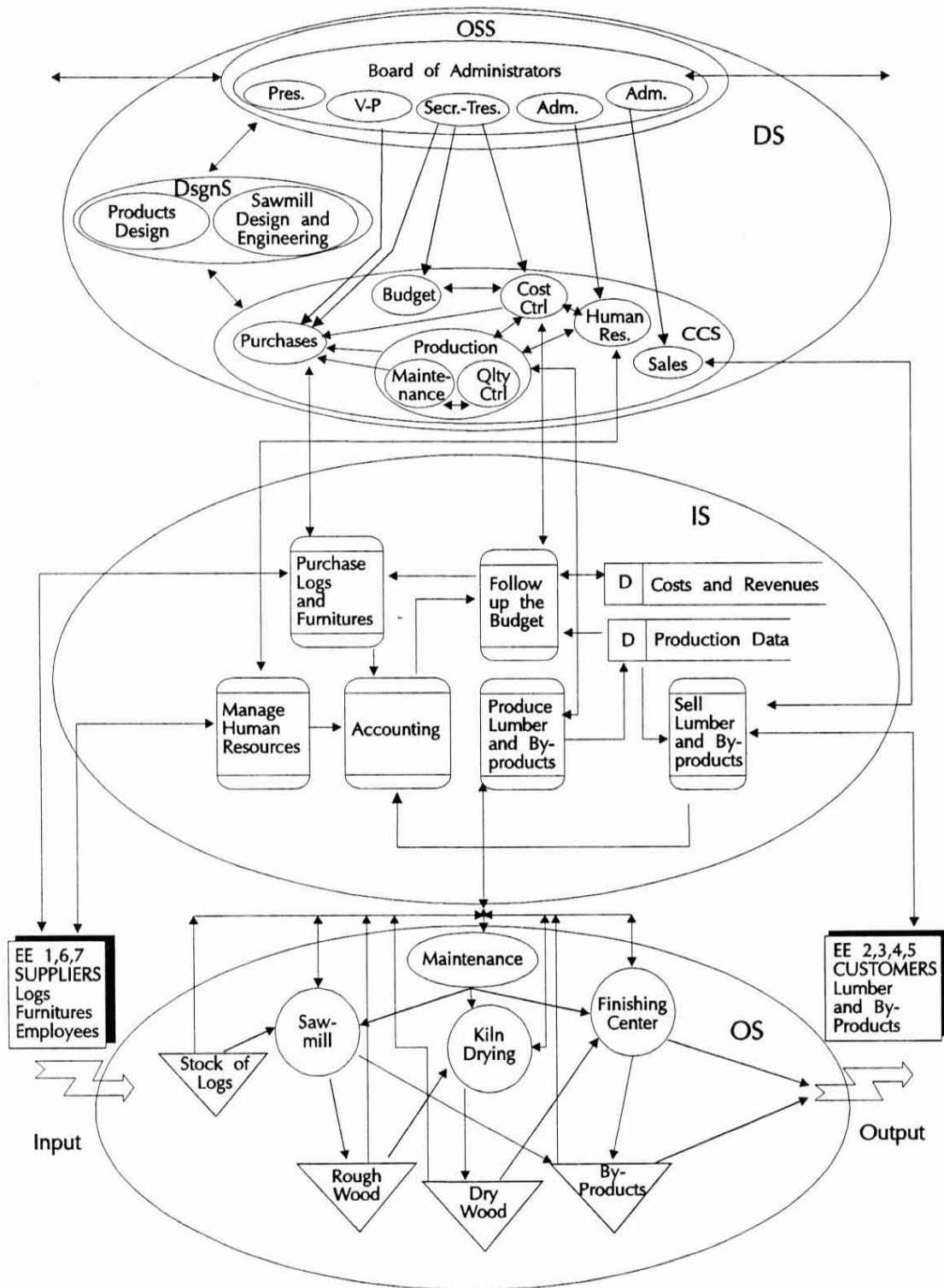
Fig. 9.   The sawmill system: an overall view.

CONCLUSIONS

In recent years, the need to bring about a comprehensive view of sawmill systems has arisen. The complexity of sawmill systems grows as new technologies resulting from information science allow the interconnection between sales tools, accounting systems, and processing machines. In an attempt to overcome this complexity, the systemic approach is proposed as an alternative to provide an overall representation of the sawmill as a manufacturing system.

In this approach, the sawmill is divided into three sub-systems—the operating system, the information system, and the decision system. These three sub-systems are modeled using different formalisms. Existing symbolisms have been adapted to represent the OS and the IS. They have been completed by a representation of the DS in an integrated and comprehensive representation of the mill as a whole.

This new vision of sawmills allows a different approach in diagnostic. Through the description of the sub-systems, possible causes of the problems encountered in the organization can be detected. In the overall representation, the relative importance of each possible source of problems and their interactions can be considered. Only at this level can we decide which degree of priority must be given to each particular problem and what might be the impact of improving one particular function. This very general point of view makes it possible to consider the relevance of the objectives of the organization. It facilitates the adoption and sharing of new strategies and new visions of the organization. Using this approach, it is possible to situate the mill in its environment and to adopt the strategies best-suited for its development.

Sawmills are very complex and systemism is an attempt to master this complexity. The method discussed here can be successfully applied to the sawmill industry, as is done in other manufacturing sectors. Our attention has been focused for too long on microscopic problems in sawmills, and it is time for a more comprehensive approach.

REFERENCES

ADAMS, E. L. 1984. DESIM: A system for designing and simulating hardwood sawmill systems. General Tech. Rep. NE-89. USDA Forest Service, Northeastern Forest Exp. Sta., Princeton, WV. 10 pp.

BAUDIN, M. 1990. Manufacturing systems analysis. Yourdon Press, YP Computing Series, Englewood Cliffs, NJ. 360 pp.

BEAUREGARD, R., M. BEAUDOIN, D. AIT-KADI, AND J. P. MONGEAU. 1993. A systemic approach for sawmill modeling: A case study. Working paper. Département des sciences du bois, Université Laval, Québec, Canada Nov. 1993. 41 pp.

CARINO, H. F., AND J. L. BOWYER. 1981. Sawmill analysis using queuing theory combined with a direct search optimizing algorithm. Forest Prod. J. 31(6):31–40.

GANE, C., AND T. SARSON. 1979. Structured system analysis: Tools and techniques. Improved System Technologies, New York, NY. 373 pp.

HALLOCK, H., AND D. W. LEWIS. 1971. Increasing softwood dimension yield from small logs—Best opening face. Research Paper FPL 166, USDA Forest Service, Forest Prod. Lab., Madison, WI. 12 pp.

HOLEMO, F. J. 1971. Inventory management—the tool and the need—in lumber production. Forest Prod. J. 21(1):12–16.

LE MOIGNE, J. L. 1990. La modelisation des systèmes complexes. Ed. Bordas, Coll. AFCET-Systèmes, Paris, France. 180 pp.

MANESS, T. C., AND D. M. ADAMS. 1991. The combined optimization of log bucking and sawing strategies. Wood Fiber Sci. 23(2):296–314.

MANTHA, R. W., A. MARTEL, AND D. PASCOT. 1988. Concepts and modeling formalisms for the development of computer integrated organizational systems (CIOS). Working paper. SystemOID Inc., Operations and Decisions Systems Department Faculty of Administrative Sciences, Université Laval, Québec, Canada. 97 pp.

MONGEAU, J. P., AND M. GRONDIN. 1992. Sawmill simulation, a new approach using OOP, in Proceedings of Division 5 Conference on Forest Products, IUFRO, August 1992, Nancy, France. 2:598.

SALVENDY, G. 1982. Handbook of industrial engineering. J. Wiley and Sons, Purdue University, Lafayette, IN.

TOCHIGI, T., R. AMEMIYA, C. TADOKORO, AND H. HASHIMOTO. 1988. Improving production systems of timber—Processing plants I. Development of the computer-simulation procedure to design the production line. Mokuzad, Gakkaishi 34(4):314–319.

WAGNER, F. G. 1982. Simulation modeling—A useful

tool for sawmill decision making. Ph.D. thesis, Mississippi State University, Forest Resources, Wood Science, and Technology, Mississippi State, MS. 91 pp.

ZENG, Y., AND J. W. FUNCK. 1990. SAW3D: A computer optimization program for log breakdown. Technical Forum Presentation at Annual Meeting of Forest Products Research Society, Salt Lake City, Utah, June 26, 1990. 8 pp.