A SYSTEMIC APPROACH FOR SAWMILL MODELING

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ABSTRACT

To illustrate how to perform sawmill modeling through the systemic approach, an independent sawmill and a sawmill integrated to a pulp complex were selected and modeled. Applications of a methodology for modeling the operation, information, and decision subsystems are presented. Comprehensive diagrams assembling the different subsystems for both sawmills are built.

The fitness of this approach for the diagnosis of integration problems is shown. Examples of integration problems between production and administrative information systems, as well as organizational aspects of integration, are discussed. The systemic models appear to be useful tools to share a common vision of the organization and its mission.

Keywords: Systemic modeling, diagnosis, integration, operation systems, information systems, decision systems.

INTRODUCTION

Manufacturing systems are complex matters. The large number of processors, transactions, and data to be handled make it difficult for the decision-maker to always consider the overall system. Often, the actions taken do not bring about the expected results. Among manufacturing systems, sawmills exhibit one important particularity. Wood, being a highly variable biological material, yields a variable product mix. Because of the difficulty in predicting the product mix from a given input, in many instances, the sawing process is performed in two different steps. The first step,

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the log breakdown, produces stocks of semifinished lumber. Based on these stocks, the lumber is sold on a highly volatile commodity market. Hence, when orders are received, the second step identified as the finishing operation (drying, remanufacturing, planing, sorting, packaging) is performed. This type of process in two steps implies additional costs for stocking semifinished goods but allows more flexibility in the sawmill operation itself. To these particularities of the sawmill industry, the usual functions of machine operation and maintenance, purchases and sales logistics, human resource management, and planification must also be considered in order to draw a complete picture of the complexity of such a manufacturing system.

The need for a comprehensive vision of sawmills instigated the development of a systemic modeling approach (Beauregard et al. 1994) to understand the complexity in sawmill analysis. This methodology should be relevant for sawmill diagnosis as well as for systems reengineering. The main objective of this paper is to illustrate how to build a systemic model of sawmills. A secondary objective is to illustrate how these systemic models may be put to work in the diagnosis of integration problems. In order to illustrate the main concepts of this approach, two sawmills are considered in this paper.

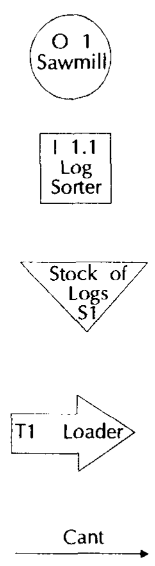
In the first section, the methodology of this systemic approach will be briefly presented. In the second part, two different sawmills will be modeled using this methodology. Finally, based on the analysis of the models developed previously, diagnostic aspects will be discussed, and conclusions on the usefulness of this modeling methodology will be drawn.

METHODOLOGY

This modeling approach is based on the concept of "System." In order to provide a general point of view, the systemic approach considers three subsystems: the Operating System (OS), the Information System (IS), and the Decision System (DS). This concept represents the conversion of a defined input into a desired output on a regular basis through an OS where the physical transformations take place. The DS is the component where the capacity to determine the objectives of the system, to adjust its evolution over time, and to coordinate and control day-to-day operations is located. The last subsystem, the IS, is the link between the DS and the OS. This is where data on the operations are gathered and processed in order to feed the DS. In return, the DS uses the IS to address its decisions to the OS. The IS is also the memory of the system.

To develop more on the systemic modeling approach, the conventions must be presented. The Operating System (OS), where material is handled and processed, is modeled using a formalism adapted from a standard representation (Fig. 1) of the American Society of Mechanical Engineers (Salvendy 1982). The Information System (IS) is represented by a well-defined formalism called Data Flow Diagramming (Gane and Sarson 1979). The symbols used for the IS representation are presented in Fig. 2. This symbolism is similar to the OS formalism in regard to the respective entities of form, time, or space processors. According to LeMoigne (1984), the Decision System (DS) is organized into three subsystems: the Objective Setting System (OSS), the Design System (DsgnS), and the Control and Coordination System (CCS). The External Entities (EE), as the name indicates, are not part of the system, but simply a source or sink of information or material. They do, though, determine the boundaries of the system.

To achieve this modeling, pertinent data must be collected. In order to model the OS, all material processors, from input to output, should be identified and described using the Flow Process Chart, defined by Salvendy (1982). For the description of the IS, it is necessary to collect a specimen of all the information that circulates, electronically or on paper, in the organization. This will allow representing the Data Flow Diagramming as described in Gane and Sarson (1979). For the description of the DS, the organization chart might constitute a good start. It must be com-



Operation	These are form processors which physically transform some input material into different output. The circle contains the name of the processor preceded by an identifier formed of the letter O followed by a number.
Inspection	Material going through an inspection is tested against a set of criteria and leaves on different flows depending on the results. The square contains a name preceded by an identifier formed of the letter I followed by a number.
Stock	This is a time processor, it designates an allowed accumulation of material in general. The triangle contains a name, followed by an identifier formed of the letter S and a number.
Transport	Space processor represents the explicit use of a transport system between two operations. Its name is placed in the arrow, preceded by an identifier, formed of the letter T followed by a number.
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 beside the arrow to designate the state of the material flow at any stage.

FIG. 1. Pictograms used in the Material Flow Networks (adapted from Salvendy 1982).

pleted by interviews with the sawmill director, with all the people responsible for any major function in the system, and with a representative number of employees. To complete this process will usually necessitate several iterations of data collection, modeling, and validation.

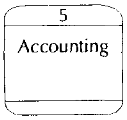
To illustrate the concept of the modeling approach, two sawmills were selected: an independent sawmill and a mill integrated to a large pulp and paper company. These two mills are representative of the very efficient small logs softwood sawmills in Eastern Canada. The sawmills are different in their organization as well as in their objectives. Using the systemic modeling to represent these two types of sawmills will show the robustness of the approach.

The independent mill tries to generate maximum profits in the sole operation of the sawmill. For the integrated sawmill, the overall performance of the company is evaluated on the operation of many sawmills and a few pulp and paper mills, thus providing more combinations for optimization. Lumber production can be considered as a marginal activity when compared, on a capital invested basis, with other sectors of the company. Forest production companies often buy sawmills to stabilize their wood supply for pulp and paper mills. These differences between the two types of companies must be considered in the modeling. The choice of these particular mills was guided by their technology and data accessibility on mill operations.

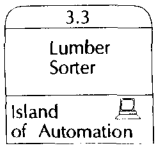
The independent sawmill is a softwood mill, producing about 35 million board feet of lumber per year on one eight-hour shift per day, five days a week. It is located at the Canada–Vermont (USA) border. The integrated mill produces about 120 million board feet of softwood lumber per year on three eight-hour shifts per day, five days a week. It is situated in the boreal forest, in the Lake Saint-Jean area, in Quebec. It is part of a kraft pulp mill complex, with three other sawmills all within the framework of a larger forest product company.

MODELING THE INDEPENDENT SAWMILL

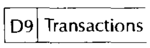
Figure 3 shows a systemic representation of the independent sawmill. The main input of the system consists of spruce and fir logs pur-



Data Processor — *These are data processing functions performed by the processing entities (resources* of the organizational system). The identifier is found in the upper part, in the middle is the name, while the lower section contains the resource used to transform the input into output.

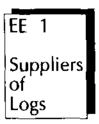


Data and Control Processor — This symbol represents data processor as well as effective material process controler. An example of this being the Lumber sorter which effectively sorts lumber and also generates a lumber tally at every shift.



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.

Data Flow — The directed arcs are used to represent the circulation of data elements between a process and a data store, external entity or another process. It may be identified by a name and it contains a list of data elements.



External Entity — Source or sink of information in the IS and of material in the OS. All systems must contain at least an EE as source and at least one as sink. The double square contains the name of the EE preceded by the identifier formed of the letters EE followed by a number.

FIG. 2. Pictograms used in the Data Flow Diagrams (adapted from Mantha et al. 1988).

chased on the free market in the New England States and is represented here by log suppliers (EE 1). The other inputs are energy (hydroelectricity) and labor. The main output is random length lumber, planed or rough, green or dry, sold to lumber customers (EE 2). By-products are wood chips, sawdust, shavings, and bark. They are also sold to different outside customers (EE 3, 4, and 5).

The Operating System (OS)

Starting from the context diagram of the whole system (Fig. 3), each subsystem can be blown up into more detailed views. The OS is the subsystem where material is handled and processed. Figure 4 presents a model of the Operating System, which is called the context diagram of the Material Flow Network. Logs entering the OS are stocked (S1) and then sent through the sawmill (O1). At the output of the sawmill, rough lumber is stocked (S2) for a while and then kiln-dried (O2). When dry, the lumber is stocked again (S3). Finally, all lumber is processed through the finishing center (O3) to be planed, graded, and packaged for shipment.

Each processor composing this diagram can itself be further expanded. These successive expansions are called hierarchical modeling. The sawmill (O1), being the main processor of the OS, is blown up into a detailed representation (Fig. 5) in order to understand the process better. Logs are entered in a soaking bin (S 1.1) and then transferred to a one-axis infrared shadow scanner (I 1.1). This measuring device separates the logs into two categories: the large logs, processed through a carriage headrig (O 1.2), and the small logs, sent through a chipper canter twin bandsaw headrig (O 1.6). All the slabs or cants coming from the two lines are sent either to the horizontal resaw (O 1.3), the double-arbor gang resaw (O 1.7a), or directly to the optimized edging center (O 1.4). Finally all boards go through optimized trimming (O 1.8) and then to the lumber sorter (I 1.2) to be separated and stocked by dimensions. Some machine centers (O 1.3, O 1.8, O 1.7a) have remanufacturing capability, shown by retroacting arcs.

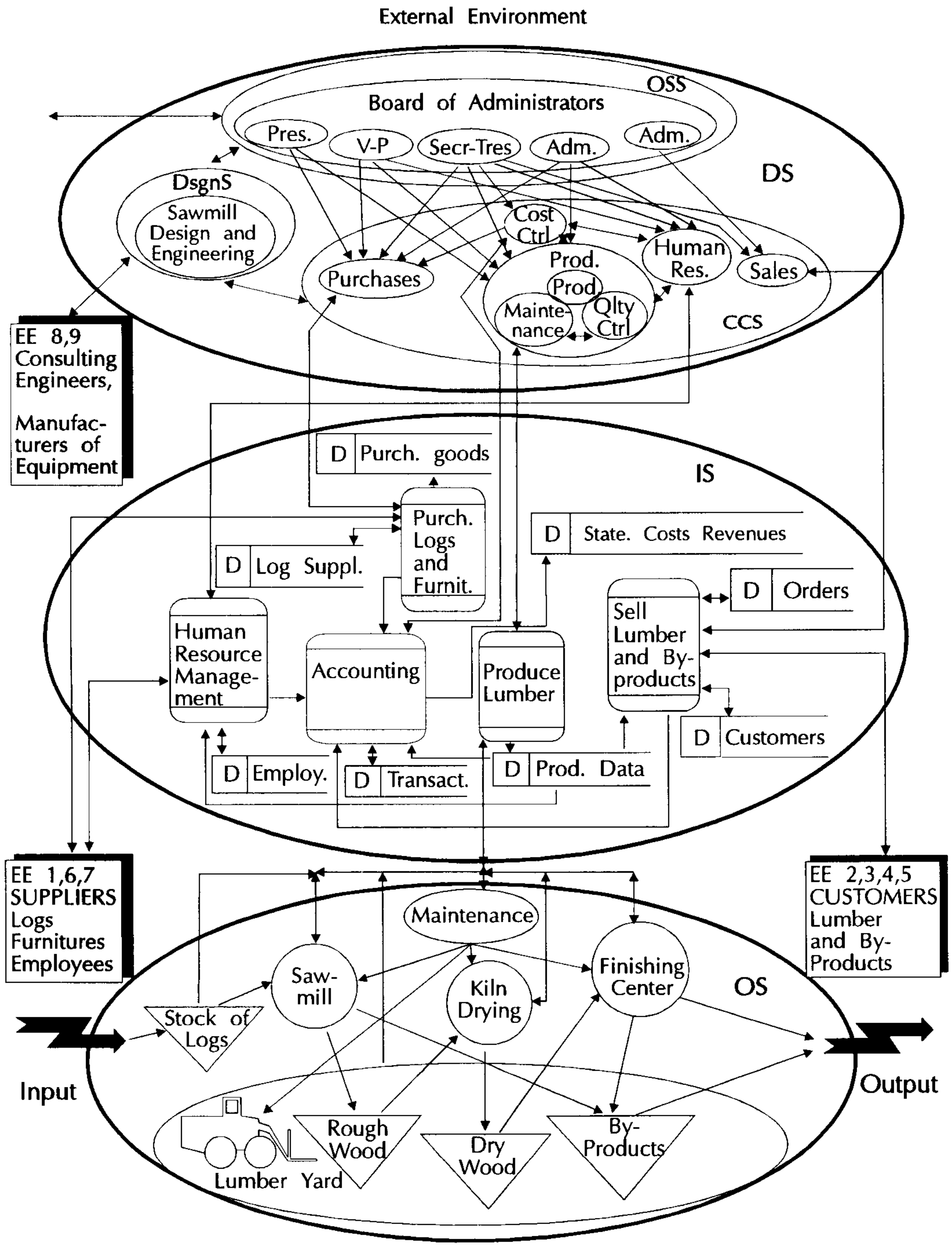


FIG. 3. Overall representation of the Independent Sawmill.

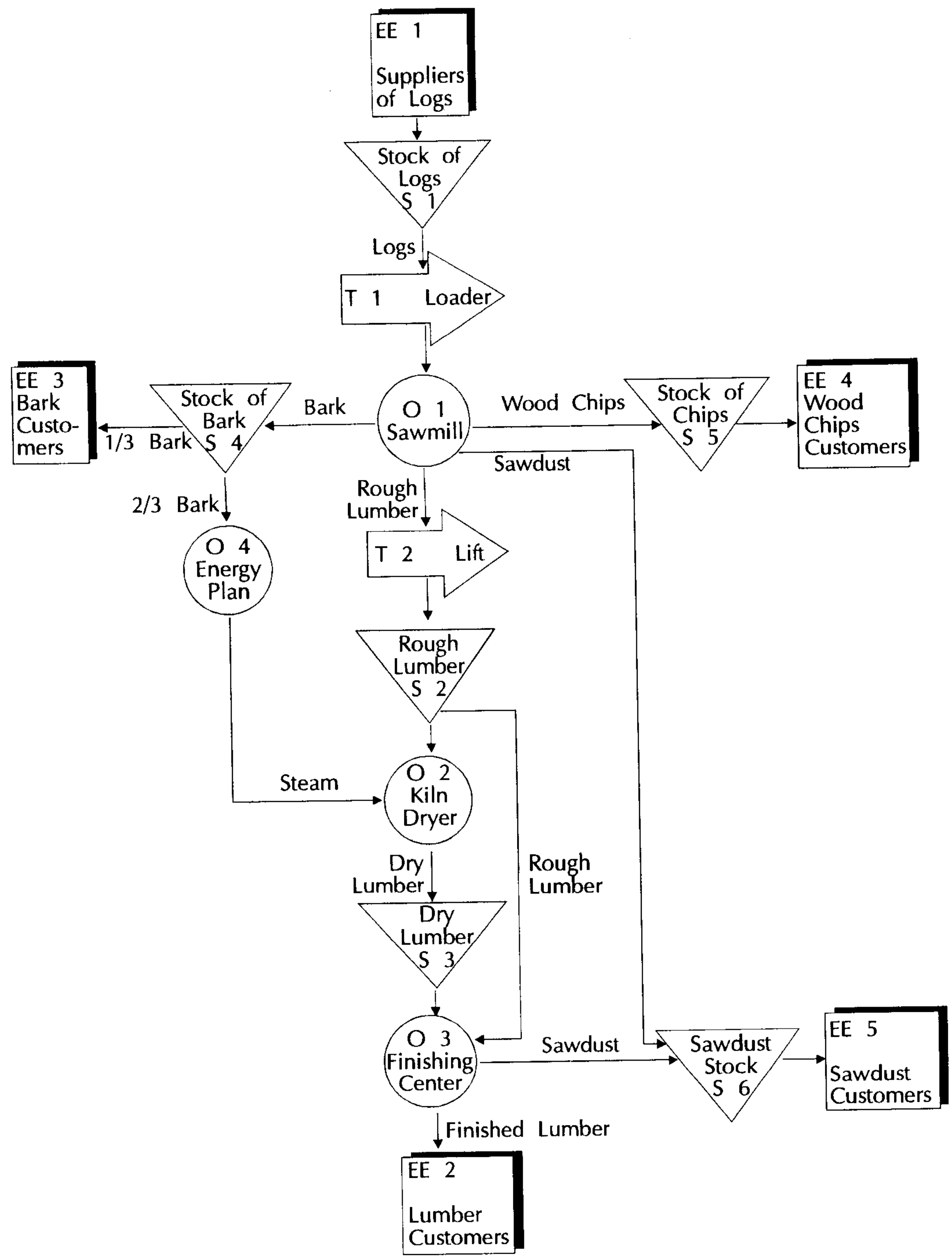


FIG. 4. A view of the Operating System of the Independent Sawmill: The context diagram of the Material Flow Network.

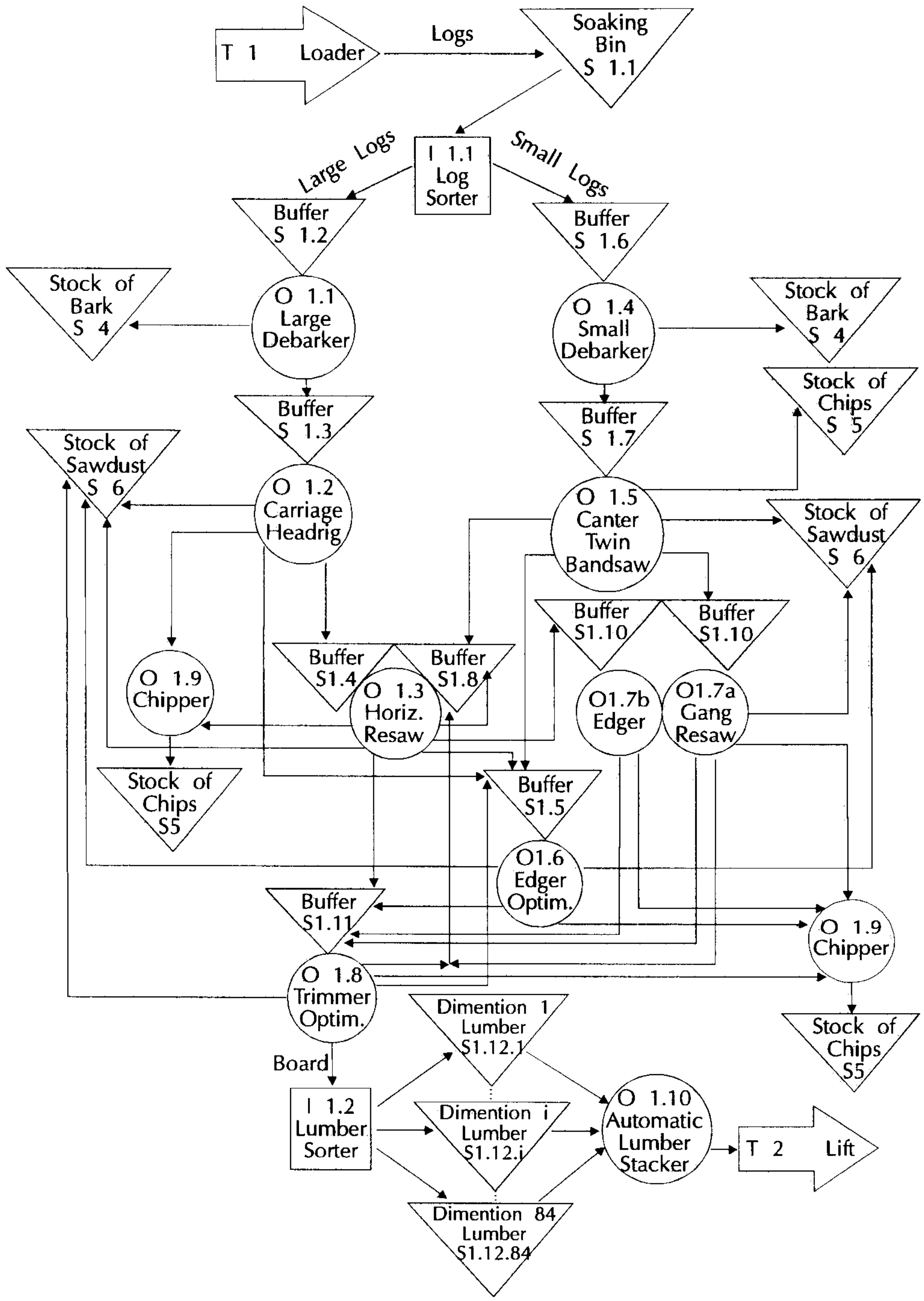


FIG. 5. Expanded view of the sawmill processor (O 1).

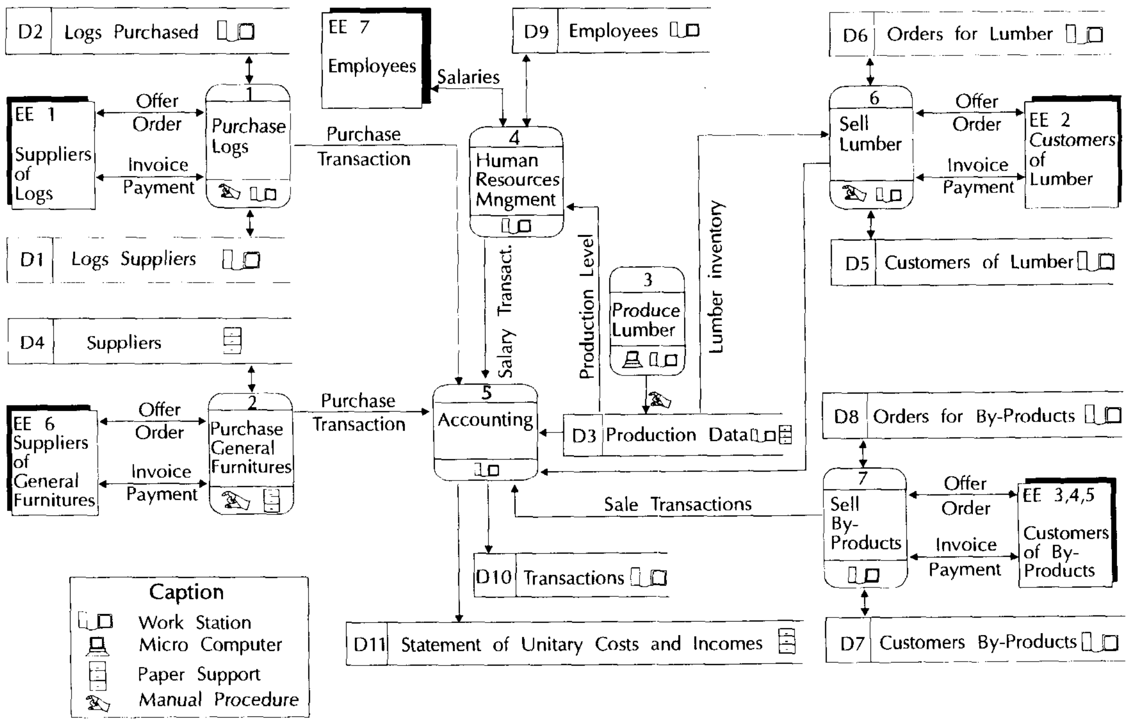


FIG. 6. The Information System of the Independent Sawmill: The context diagram of the Data Flow Diagram.

The Information System (IS)

The Information System is the subsystem where data are gathered and handled to assist the Decision System in piloting the Operating System. In IS modeling, the basic functions of purchasing, selling, human resources managing, producing, and accounting must be represented. Figure 6 presents a model of the IS called the context diagram of the Data Flow Diagram.

First, the purchasing units, on the left-hand side of the diagram, are composed of data processors 1 and 2, responsible respectively for log and for all other purchasing information handling. The structure of a purchasing module is made of a processor exchanging information with the suppliers (EE 1 and 6). The processor usually accesses and updates two data stores; one contains data on the suppliers (D1 and D4), and another contains information on what has been purchased (D2). In this case, it must be noted that no information is kept on general furnitures purchased. On the right-hand side of the diagram, the sale processors (6 and 7) can be found. They are structured in a similar manner as are the purchasing units. At the top center of the diagram, the module handling data on human resource management is represented (4). Finally, the accounting processor (5) registers all transactions of purchase, salary, and sale. Using production and transaction data, the accounting processor produces statements of unitary costs and income (D 11).

The tools described until now constitute the administrative part of the IS. Data on the production itself are handled by the produce lumber processor (3). It is of interest to model in more detail this processor (Fig. 7) because of its intimate links with the decision and operation aspects of running the sawmill. Figure 7 also shows that islands of automation (3.1, 3.2

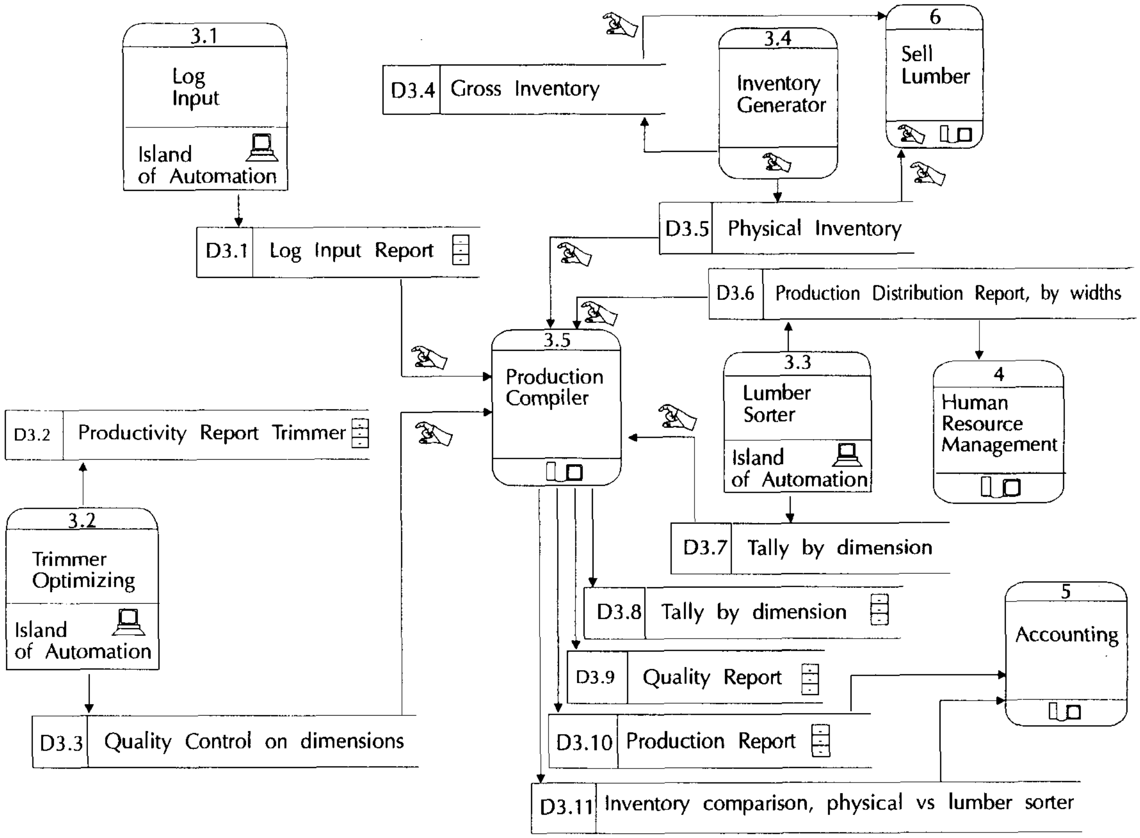


FIG. 7. Independent Sawmill: Expanded view of the Processor 3: Produce Lumber.

and 3.3) are major sources of primary data. The processor (3.1) generates information on log input. Processor (3.2) generates data on the trimmer optimizer activities. Finally, the lumber sorter (3.3) generates detailed information on the output of the sawmill. A hand icon on the arcs indicates that data are transferred manually from these data processors to the production compiler (3.5) (Fig. 7). The bottom part of data processor icons presents which computer or human resource is used. Microcomputers used by the islands of automation are neither networked between themselves nor connected to the workstation used by the production compiler. Figure 7 also features how information is gathered on inventories (3.4) and how production data are transferred to other units like human resources management, accounting, and sales. The file cabinet icon used with some data stores indicates memory kept on paper support.

The Decision System (DS)

The Decision System, represented in Fig. 3, performs three main functions. Hence, it is organized into three subsystems: the Control and Coordination System, where the operations are conducted; the Design System, where the design or redesign of the sawmill is performed; and the Objective Setting System, where the objectives and the evolution of the system over time are determined.

The Control and Coordination System fulfills functions of purchase, human resource management, production, cost control, and sale. There is one designated director for cost

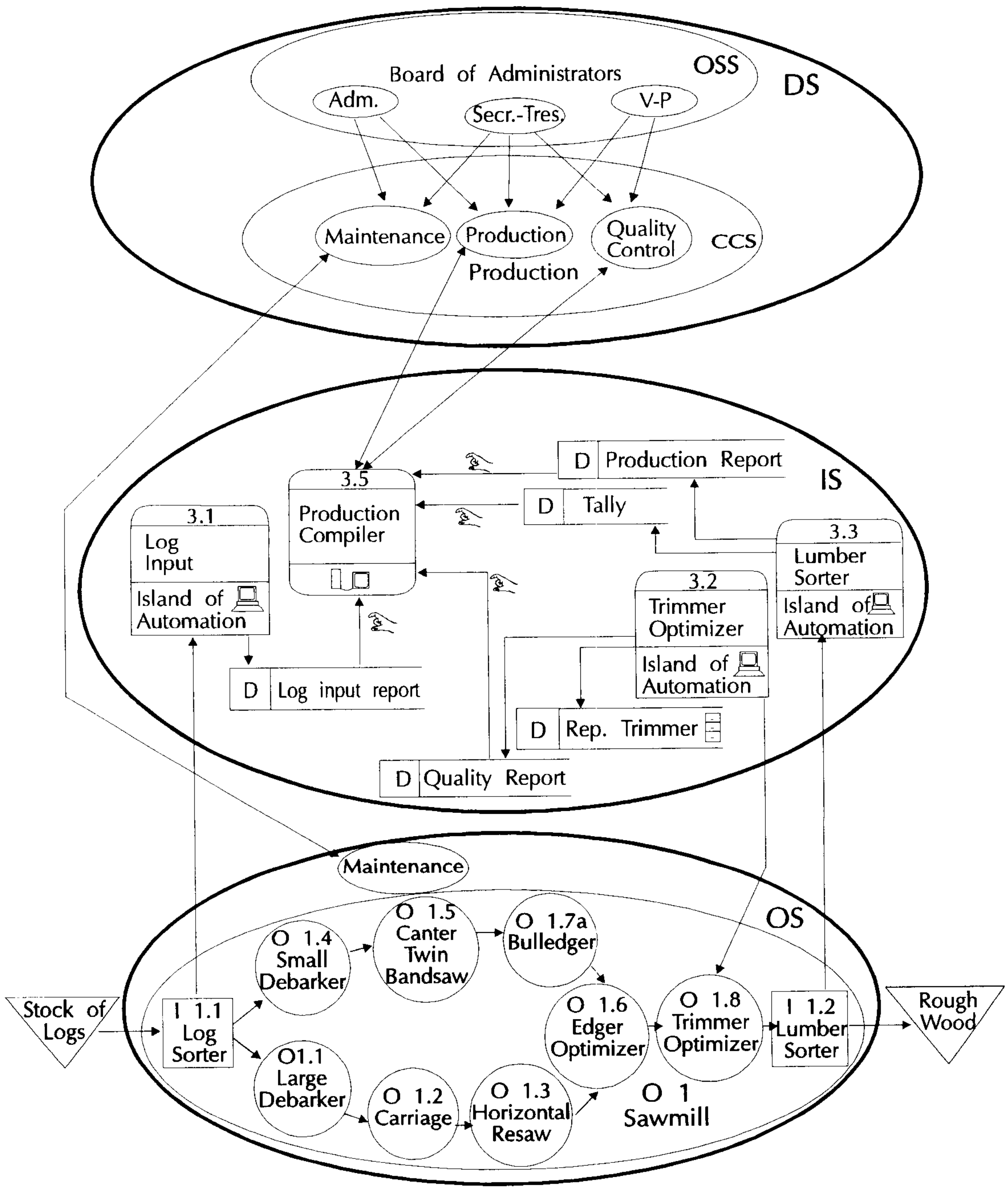


FIG. 8. Expanded view of the Production Subsystem.

control and for the sale of lumber, but other functions are assumed by more than one person. Purchasing of logs is performed by at least two different persons, the secretary-treasurer and the president. At least three persons are involved in production control. One administrator acts as production and maintenance foreman, the vice-president acts as director of production and quality control, and the secretary-treasurer compiles production data on a daily basis. Because of this, the secretary-treasurer is often the first to react to deviations in production. He is also responsible for the implementation and maintenance of all electronic devices in the sawmill. Human resources are managed by the same three persons involved in production control. Figure 3 illustrates this situation of having many people responsible for each function by the multiplication of intricate arcs between the administrator and the direction entities, the same person acting simultaneously as administrator and director.

The Design System is rather informal because of limited financial resources. No particular structure exists to perform any design function. However, the sawmill evolves continuously by giving contracts to engineering consultants or manufacturers of equipment for the conception and the realization of their projects. This situation is modeled in Fig. 3 by the links between the DS and external entities 8 and 9, representing the consultants and manufacturers. The projects realized in recent years provided the capacity to produce dry lumber and gave the company an overcapacity for remanufacturing, planing, and packaging. These developments were made in order to increase the flexibility of the organization.

The Objective Setting System is represented by the board of administrators, which is composed of the owners of the company. The main shareholder of the company is also the president. He tends to limit his role to the OSS. The secretary-treasurer of the company is committed to all aspects of the operations of the sawmill. Most decisions are done informally. Both president and secretary-treasurer assume a preponderant role in the DS as well as an effective leadership. This leadership is rooted in the familial character of the organization. Such an elusive behavior can hardly be represented by arcs between entities.

Diagram of production activities in the independent sawmill

As was done with OS and IS modeling, the context diagram of the general model (Fig. 3) can be expanded to expose particular phenomena. For example, Fig. 8 presents a blowup featuring only the activities related to the production, in all three subsystems. This can be done in order to highlight one specific function like maintenance. Maintenance interacts with all processors in the OS. It must encompass all information about these processors, their structure, and their interactions. In this particular case, the most urgent job is always to repair broken machines. Besides this task, a routine of prevention is implemented. Every machine is assigned a schedule of preventive intervention. To support the maintenance function, stocks of mechanical or electronics parts are scattered on several locations. As shown in Fig. 8, no central data processor or data store exists for the management of these parts. The direction of the maintenance function is assumed, directly from the DS through the OS, without significant use of the IS. All information is kept in mind by the people involved.

Figure 8 also provides more insight on how the log sorter (3.1 in IS and I 1.1 in OS) and the lumber sorter (3.3 in IS and I 1.2 in OS) are of crucial importance in the control of the sawmill input/output. In fact, the log sorter and lumber sorter processors, completed by the trimmer optimizer, are the main sources of primary data on production. They are also important effectors of production decisions.

Figures 3 and 8 are examples of how systemic approach apprehends complexity. They are only models, but for the first time, the sawmill system is considered as being more than the sum of its parts.

MODELING THE INTEGRATED SAWMILL

The interest in modeling the sawmill integrated to a pulp mill complex is to illustrate how the systemic modeling approach can represent this organizational integration as well. This integrated complex is organized into three levels: the local or sawmill level, designated in the various diagrams by the letter (S), includes one sawmill; the division level, designated by the letter (D), contains a kraft pulp mill and three sawmills and a finishing center; and the third level, designated by the letter (H) for head office, oversees the whole company, which operates three such pulp and paper complexes.

Figure 9 presents an overall view of the integrated sawmill. In this model, only the entities related to the operation of the sawmill are represented. It is not the model of the whole enterprise, but the model of the sawmill as it is integrated in the larger company. The main input of the sawmill is whole trees harvested on public land under an agreement with the Ministry of Natural Resources in the province of Québec (EE 1). The output of the sawmill is studs and random length lumber sold to lumber customers (EE 2).

The Operating System (OS)

The lowest part of Fig. 9 presents the material flow network of the integrated sawmill. Forest operations processor (Od 1) is responsible for harvesting the trees and transporting them on the limits of the sawmill. This operation is not under the control of the local sawmill, but the division level, hence the letter (d) associated with the identifier of the processor.

At the beginning of the sawmill jurisdiction, stems are processed through a log production center (Os 1) before entering the sawmill itself (Os 2). The sawmill operates with two production lines: one processes small logs into studs, while the other process larger logs into random length lumber. At the exit of the mill, stud bundles are piled in the yard (Ss 2) waiting to be kiln-dried (Os3) locally. Then they are taken in charge by a division transport system (Td 1) and shipped to a finishing center (Od 5). There, they are planed, eventually bar-coded, and packaged. Also at the exit of the mill, random length lumber is taken in charge by the division level right at the sawmill. It is transported (Td 1) to another establishment of the division to be kiln-dried (Od 3), and processed through a finishing center (Od 4) where it will be planed, eventually machine stress rated, and packaged. All lumber from the two preparation centers is finally taken in charge by the head office level to be sold, brought (Th 1) to two distribution yards (Sh 1 and 2), and distributed to lumber customers (EE 2).

The Information System (IS)

The middle part of Fig. 9 presents the Information System. This diagram indicates that the information is strongly organized around a central database (DB 1) at the division level. The operations of the division level like forestry (1), finishing center (4), material flow control (9) are related to this database as well as the division administration functions like human resources management (5), accounting (6), budgeting (7).

Also at the division level, the maintenance processor (2) is responsible for data handling on maintenance not only in this particular sawmill but also in the kraft pulp mill and in every sawmill of the division. It has its own database (DB 2), and as shown in Fig. 9, the maintenance IS is totally isolated from the rest of the IS.

On the right-hand side of the figure, the sell lumber processor (8) is operated at the head office level. Its function is to handle data on sale transactions with lumber customers (EE 2) and on lumber inventories. The transactions are stored in the head office database (DB 3). The division and head office IS handles large amounts of data. It was built on mainframe platforms. The IS at these levels was designed by the direction of IS at the head office level.

In the left-hand side of Fig. 9, the produce lumber processor (3) is the only one situated

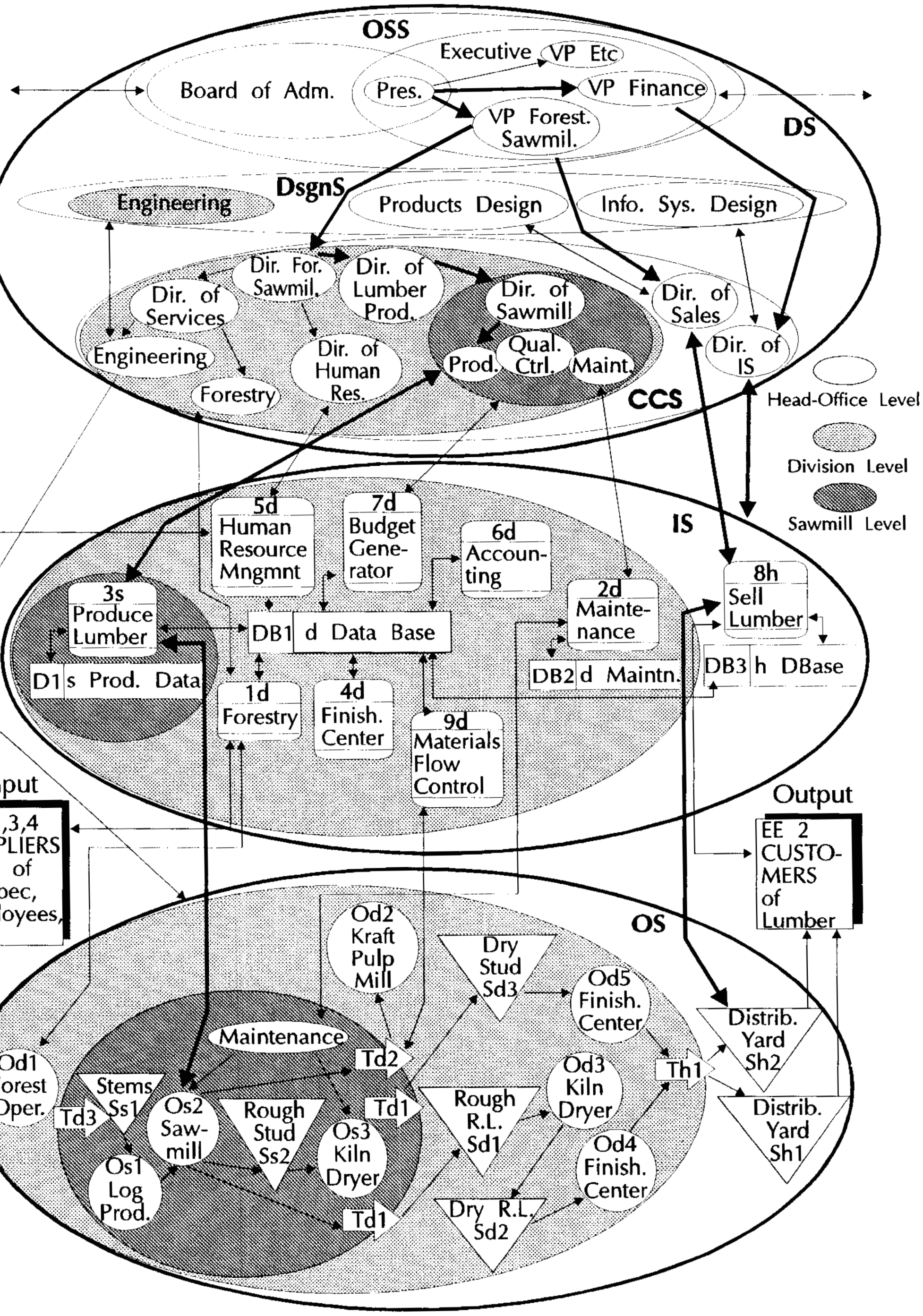


FIG. 9. Overall representation of the Integrated Sawmill.

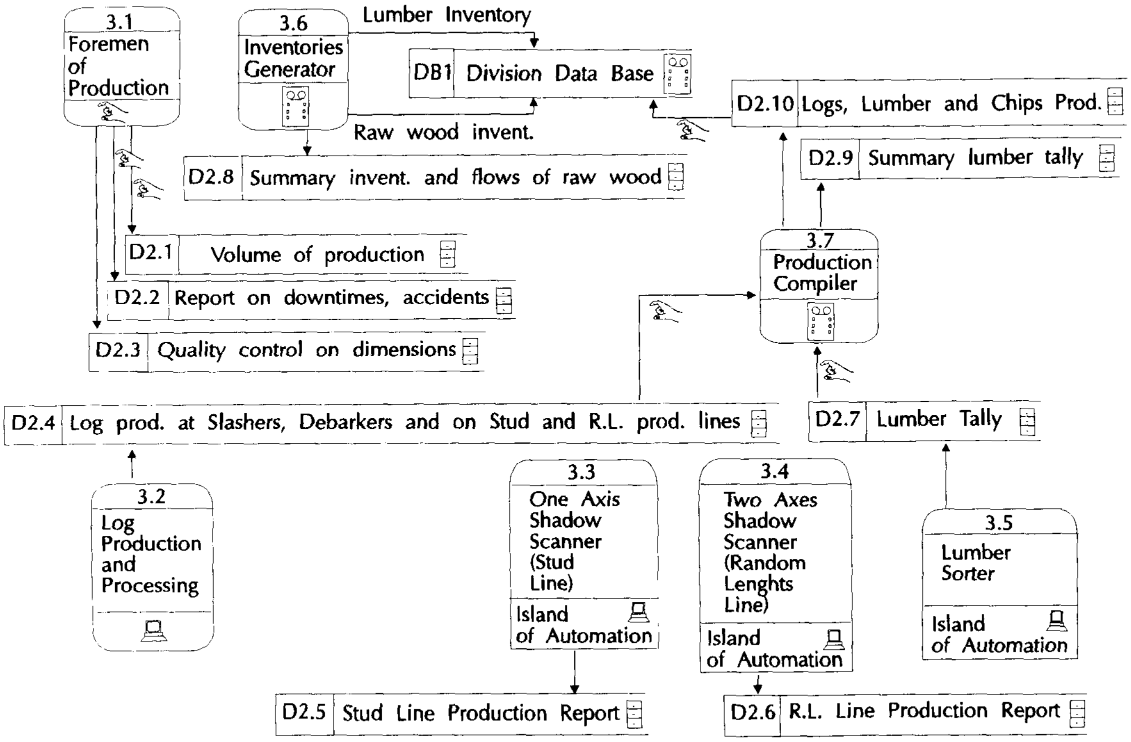


FIG. 10. Integrated Sawmill: Expanded view of the Processor 3: Produce Lumber.

at the sawmill level. It generates production and inventory data transferred in the division database (DB 1). As it also produces data for local use, it is of interest for our purpose to present an expanded diagram of this processor (3), cf. Fig. 10.

The main source of production information originates from four islands of automation. These are the log producer and processor (3.2), the one axis scanner (3.3), the two axes scanner (3.4), and the lumber sorter (3.5). These automatic devices generate bulk primary data on log production at the slasher, the debarker, and on logs processed at the stud and random length lumber production lines (D 2.4), on log transformation and on productivity at the stud line (D 2.5), at random lengths line (D 2.6), and on the tally of all lumber produced (D 2.7). They constitute the main tool used by the director of the mill to control production. Complementary information on production is also manually generated by the foreman of production (3.1), while information on inventories (3.6) is put on mainframe. The sawmill production IS has been designed locally by production people. The log production and processing unit (3.2) has been designed by local sawmill employees, while processors 3.3, 3.4, and 3.5 were designed by the manufacturers of equipment, which also provided process control devices. Reports from these four devices are printed at every shift, and the information is stored on paper by manual procedures. In fact, a very small portion of these primary data (D 2.10) is finally processed to be transferred in the division database (DB1).

The Decision System (DS)

The Decision System of the integrated sawmill can also be presented in three subsystems (cf. upper part of Fig. 9), the Objective Setting System (OSS), the Design System (DsgnS), and the Control and Coordination System (CCS). The DS of the integrated sawmill is highly organized and hierarchical.

In the OSS subsystem, two main entities can be observed: the board of administrators and the executive, which is composed of the president, a vice-president of forests and sawmilling, a vice-president of finances, a vice-president of pulp and paper, etc. The company is public, and the main shareholder is a printing and newspaper company. The role of the board is to give major orientation to the company, while the executive is responsible for the general operation and reports to the preceding. They both are situated at the head office level.

The DsgnS subsystem is much more formal and more organized than what was observed in the independent sawmill. First, there is an engineering service for the design of production centers. This service reports to the director of services at the division level. There is also a person responsible for products design, at the director of sales, head office level. The last function of the DsgnS is the Information System design. The company invests a lot of money in the development of the Information System. Most of it is conceived at the head-office level by the director of the Information System.

The CCS is well developed and hierarchically structured. The director of the Information System assumes the conception and the operation of the IS at the head office as well as at the division levels. This director depends on the vice-president of finances, though this is considered to be a development of the administrative and accounting area. The director of sales relates to the vice-president of forests and sawmilling, but is not, however, directly related to the production channel. The analog of the director of sales in the production area is the division director of forests and sawmills. Three directions are under this authority: the director of services, heading forestry and engineering, the director of human resources, and the director of lumber production, controlling all sawmills and finishing centers of the division. At the sawmill level, the sawmill director is the chief manager. Under his authority is a superintendent of production who directs three foremen of production, one per shift, and a foreman of maintenance. The very hierarchical character of the DS is well represented by the model (Fig. 9).

DIAGNOSIS

The last section on model building has shown how to make systemic sawmill models in two very different contexts. The next section presents how these models can be useful in the diagnostic of these two particular sawmills.

Independent sawmill

During the model building process, several problems that could have been detected by other methods than the systemic approach were identified. For example, in the OS, bottlenecks were observed. They could very well have been diagnosed by a sawmill engineering study like those performed by the sawmill improvement program (Von Segen et al. 1990). Similarly, in IS modeling, problems in the follow-up of purchased goods were observed. Such problems could have been observed by structured system analysis (Gane and Sarson 1979). Other problems detected in the DS could also have been detected by other methods. However, some problems can best be assessed by the systemic approach; we label them "integration problems."

A good example of an integration problem is the maintenance function. It is viewed as an integration problem because it must ensure the efficiency and reliability of the whole production system, such as the regularity of material flow, the product quality, and the maximization of the production rates at the minimum cost. During the process of model building, it was noticed that maintenance in the independent sawmill is considered to be a rather troublesome function, badly integrated to the production itself. Figure 8 shows that no record is kept of maintenance interventions. It is, therefore, impossible to evaluate maintenance costs or even the function itself. This confirms the perception that maintenance is given little attention. To begin solving this problem, the organization should develop a way of including maintenance data in the IS. Furthermore, it should reevaluate its approach to maintenance in a more comprehensive manner. For example, in the Japanese concept of total productivity maintenance (Nakajima 1989), the maintenance function is presented as a driving force for all manufacturing functions instead of being a marginal activity. This concept should be considered in the same way as in other forest product industries (Ait-Kadi et al. 1991).

A second integration problem concerns the lack of integration of "intelligent" machines in the IS design. Figure 8 presents a vision of how a few machine centers play a role in process control as well as in data generation. These machine centers, the log sorter, the trimmer optimizer, and the lumber sorter are of crucial importance for the input/output control of the sawmill. The edger optimizer could also be added to this because it performs "intelligent" process control even if it does not actually generate production data.

The first lack of integration occurs in optimization processes. Indeed, the edger and trimmer optimizers (Fig. 5) do not "talk" to each other in the IS (Fig. 7). In fact, the edger optimizer does not even appear in Fig. 7 because it generates data under a form too primitive to be used in day-to-day operations. These two machine centers use different optimization rules, which sometimes lead to closed loops whereby a given piece of wood is sent back and forth from one machine center to the other. This situation will worsen as optimizing devices are eventually considered at the bull-edger and the headrig machine centers. These devices may not only be incompatible; but a local optimization, even well performed, does not guarantee a global optimum for the entire sawing process, as was demonstrated by Maness and Adams (1991).

A second lack of integration may also occur between these machines and the administrative portion of the IS. As shown in Fig. 7, data transfer from these "intelligent" machines to the administrative computer has to be done manually every day, thus consuming considerable time and energy by a key person at the direction level. The interconnection between these islands of automation in the sawmill and their networking with the administrative computer should facilitate this data acquisition procedure.

These opportunities of evolution towards a Computer Integrated Manufacturing (CIM) concept are considered by the organization; but because of the size of the company, financial and human resources are rather limited. In this context, the vision of the problems provided by the systemic models could be helpful in providing a medium to a long-term framework for the implementation of integration solutions.

The last integration issue concerns the goal of the organization. The company is considered efficient and competitive in spite of the lack of clarity observed in the tasks of the directors (Fig. 3). The cohesion of this social system comes from the effective leadership of one or two persons and from the family character of the organization. Traditionally, the success of the enterprise has been based on the use of the best available technology, on tight cost control, and on marketing oriented toward quality products. As noticed in the DS section, in recent years the sawmill added overcapacity in finishing, remanufacturing, and kiln-drying. This orientation indicates an evolution seeking more flexibility and diversification in products; but at the same time, it will bring new challenges. The company will have to balance its activities between the sawmill itself and the preparation center, which will become more and more important in the whole system. The IS will become more complex, and integration challenges will increase. In this context, a tool to increase the flexibility could prove to be useful for the organization. The systemic model, previously sketched, can be such a tool. It will contribute to specify new goals, to identify how to reengineer the whole system in order to attain these goals, and finally to communicate them so that everyone can participate in the implementation of this vision.

Integrated sawmill

In the diagnosis of the sawmill integrated to a kraft pulp mill, only sawmill issues will be considered. We do not pretend that this level is more relevant than others in managing a large forest product conglomerate, but the objective of this project is to support decision-making for sawmills. We will, however, limit our diagnosis to two integration issues: the integration of the production IS, and the overall sawmill strategy as it relates to organizational aspects.

From Fig. 9, it is obvious that the heart of the IS is rather remote from the sawmill. Information tools are clearly at the division and head office levels. Historically, the IS was built at the head office and at the division in an accounting context rather than in a production context. The division and head office IS (Fig. 9), strongly organized around large data bases (DB 1 and DB 3), were designed by IS professionals under the umbrella of the director of IS, depending on the vice-president of finances. The local production IS (Fig. 10) was built by local human resources, according to the needs expressed by the director of the sawmill (Fig. 9). The result is a locally handcrafted production IS, which is quite uncoupled with the strongly organized division and head office IS. In fact, a considerable amount of production data is generated, as can be seen in Fig. 10; but this information is handled using manual, unintegrated procedures. Reports are printed on paper and stored in file cabinets to be used in day-to-day operations. The task of feeding the division database (DB 1) is considered surplus work useful only for control needs of upper management levels. There is a need for more integration between the production IS and the other sectors of the IS. The highly hierarchical organization of the DS does not facilitate such an integration. Indeed production issues are under the authority of the vice-president of forests and sawmilling, while IS issues are under the authority of the vice-president of finances. Since there are very few formal horizontal channels of communication in this organization, such a question would have to be dealt with by the president of the company.

The second integration issue is the overall sawing strategy of the company as related to organizational aspects. At the moment, no optimizing device is used in the sawmill, and the lumber yield is rather low. High quantities of wood chips are produced, which is coherent with the integration to a kraft pulp mill but might affect the profitability of the sawmill itself. The general approach for the sawmill is to reach overall low-cost production based on the heavy use of automation. This approach was decided from the point of view of the production line in the DS (cf. Fig. 9 director of forests and sawmilling, director of lumber production, and director of sawmill) under the authority of the vice-president of forests and sawmilling. According to the same vice-president, the point of view of the director of sales is to generate the maximum income from given products or from given raw material. This point of view resulted in the development of machine stress rated lumber, which contributes positively to the overall operation. These two visions, without being contradictory, are different. The two are effective in the orientation of the sawmill operation, but they are not well articulated in the DS. The two lines connect only at the vice-president level (Fig. 9), which might be a little high for the regulation of operations. Once again, this type of highly hierarchical structure might lead to a lack of flexibility, to friction, and even to conflicts. Less bureaucratic modes of organization should be considered. Abundant literature discusses this problem, and often the formation of teams around products is proposed (Tapscott and Caston 1993; Warnecke 1993) to replace hierarchical structures. These teams, being more customer and less internally oriented, would be able to arbitrate goals more easily. The systemic modeling approach could contribute to the design of such a team-oriented structure. It would be a fitting tool to manage the issue.

CONCLUSIONS

The two case studies outlined present how a systemic modeling approach can be used to provide overall representation of sawmills. The emphasis was placed on the application of the method in two different contexts, an independent sawmill and a sawmill integrated to a pulp and paper complex. The case studies illustrate how the methodology can be applied to these two very different contexts, thus confirming its robustness as a representation tool.

The second objective was to present how the systemic models presented could be used in the diagnostic of sawmill manufacturing systems. The two applications led to different analyses and conclusions. It would be false to pretend that one case is simple and the other complex. They are very different. The analysis of the independent sawmill mainly considered operations, while the one for the integrated sawmill emphasized organization matters.

The two analyses suggest that the systemic approach is particularly fitted for the identification of integration problems. In both cases, the need for more integration between production and management IS was outlined. In the case of the independent sawmill, this need is restricted by lack of human, organizational, and financial resources. In the case of the integrated sawmill, the resources are available, but the movement might be inhibited by the rigidity of the organizational structures.

The second common issue observed in the two studies was the question of the overall strategy of sawmill systems. In both cases, we observed the need for a tool to represent the goal of the sawmill as related to its functions and structures. The systemic modeling approach was identified as a way to define the goal of the sawmill, to specific ways to reach this goal, and as a tool to communicate a vision.

In future research work, the methodology should be further developed in order to add quantitative capacity to its relating mechanism: the arrows between the entities in the different models. The addition of such cardinal capacity to this modeling approach would improve its power of representation of processes and processors. Another limitation is the relative inability to represent human factors. The complexity of human behavior in work situations, formation or authority remains largely unexplained by this approach.

More work should also be done in order to use this modeling approach in a prospective context. The modeling performed in this study suggests that the systemic approach is useful in the representation of existing sawmills, but it would be of interest to illustrate how it can be used to predict the behavior of the system to changes in the environment. Lumber markets are evolving. Lumber customers have increasing requirements from sawmills. The conception of more flexible sawmill systems is an issue that could be addressed with the systemic modeling approach.

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