A DECISION SUPPORT SYSTEM TO ASSIST IN CONTAINERBOARD LOGISTICS MANAGEMENT

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ABSTRACT

Management decision-making must be responsive to changing economic conditions, dynamic internal business circumstances, and an expanding set of operational and strategic issues relevant to business policy-making. Decision-making in this environment requires timely access to accurate and complete information pertinent to specific business situations. Meeting this requirement is complicated by a narrowing time frame in which highly volatile data must be organized and analyzed before it can be assimilated into the decision-making process. Effective management of containerboard production and distribution requires an information system that supports decision-making in all phases of business activity: operational control, management control and strategic planning. The Brownboard Order And Rollstock Distribution System (BOARDS) integrates management science and operations research with advanced computer technology and human decision-making to support demand-based production planning in the corrugated shipping container industry.

American Management Systems, Inc., a management consulting and system development firm, developed BOARDS for the Shipping Container and Containerboard Marketing Division of Weyerhaeuser, a company principally engaged in the manufacture, distribution and sale of forest products. BOARDS operates on a dedicated Hewlett-Packard 3000 Series II computer with 512K bytes of main memory. Nine distinct IMAGE data bases constitute the system's foundation. Over one hundred BOARDS functions written in COBOL, SPL and FORTRAN have been aggregated into six integrated subsystems. Most of the system was installed in the fall of 1978; further development is underway and will be installed early in 1979.

INTRODUCTION

The corrugated shipping container industry is highly sensitive to dynamic market and economic conditions. Increased competition, technological advances that have yielded attractive substitutes, and tightening environmental regulations are factors contributing to the rising production costs and unstable demand facing the industry. When the lumber business is prospering, the integrated forest products manufacturers (those companies that make lumber, brownboard and boxes) run their containerboard mills at full capacity in order to consume prodigious quantities of wood chips. Flooding the market with containerboard in periods of depressed box demand results in excess containerboard inventories and narrowing profit margins. Containerboard inventory distribution, in addition to supply considerations, is also an integral part of sales and profit performance.

The corrugated shipping container producers have every incentive to adjust operating policies and planning strategies to meet the challenge of achieving production capacity and improving profit margins. Alternative means of adjusting the market conditions are to control production of containerboard at the mill; discover ways to increase demand; or institute mechanisms for supply planning, demand forecasting, and mill scheduling which result in inventory levels that are responsive to actual consumer demand and that are economically justified.

EXAMINING THE ALTERNATIVES

Mill production of containerboard typically runs in cycles; production of light-weight grades followed by heavy-weights and back to light-weights. Gradual increments in grade/basis weight production maintain an efficient cycle whereas irregular changes require substantial machine set up time, are disruptive, and drive up production costs. Extreme fluctuations in box demand do not coincide with an orderly, efficient production cycle. Satisfying uneven fluctuations in demand by increasing or decreasing production volume, while maintaining an efficient grade cycle, adds to the high operating cost of containerboard production. Therefore, production control mechanisms are expensive and undesirable. Even if production is responsive to demand, situations may still occur such that it would be cost effective to slow or shut down the mill; but generally only as a last resort.

Shipping container manufacturers have campaigned vigorously to increase demand for their product. As evidence of this, the integrated companies have chosen to enter markets for low volume, specialty containers. New foreign markets are also being explored. The continuous growth in demand for corrugated boxes that prevailed during the 1960's at 5.6% per year slowed to about 3% per year in the early 1970's and is optimistically expected to equal the growth of the U.S. economy in the long run (Business Week March 13, 1978). Efforts to generate increased demand for shipping containers continue, but are not a practical long-term solution to problems associated with containerboard inventory management under volatile market conditions.

A practical long-term strategy is to achieve improved management of existing facilities in response to consumer demand. The objectives are to minimize inventory stockpiling and to avoid lost sales due to poor inventory distribution. This is accomplished if each corrugated box shop is supplied with, or has access to, sufficient and specific quantities of brownboard needed to satisfy existing and forecasted customer orders. Containerboard Logistics Management is responsible for achieving this demand/supply balance. The difficulty associated with establishing demand-based production and planning policy is that large quantities of information must be assimilated into the logistics management decision-making process. Fluctuations in demand must be accurately monitored for each box shop and market region; up-to-date inventory levels at the box shops and the mills, and quantities in-transit must be known at all times; and mechanisms to process, track and assess the status of containerboard orders must be in place.

A system that provides this information must support containerboard logistics decision-making in all phases of management activity: operational control, management control and strategic planning. Within each type of activity, the system must support decision-making that ranges from structured (such as order entry, inventory control, consumption forecasting, and pricing) to semi-structured (such as mill scheduling, simulating policy decisions to set target weeks of containerboard inventory at the box shops, and demand/supply planning analysis).

A FRAMEWORK FOR CONTAINERBOARD LOGISTICS DECISION MAKING

The usefulness of such a system extends beyond the realm of management control. Day-to-day operational support to the box shops and containerboard mills is also achieved. Order entry, containerboard production, shipment, invoice and receipt transaction processing facilitate ongoing activities at distributed sites while simultaneously supplying a central pool of management information. Decisions to contract for additional containerboard orders or to purchase additional containerboard are based on better and more complete information by providing box shops direct access to the system.

A system to manage a demand-based production strategy must be capable of accurately capturing and monitoring consumption forecasts and converting those forecasts into orders that can be filled economically. Access to weekly box shop consumption forecasts, current on-hand and in-transit quanities, and outstanding orders provides containerboard logistics management with the information required to determine the grade and quantity of brownboard to order for each box shop in the upcoming weeks. Mill production rates, warehouse inventory levels, and trade agreement balances provided by the system are also used by management to help make economical decisions when placing orders.

A system to capture, store, process, and report information in a timely and usable manner must be responsive to dynamic market conditions to justify its use in any market. It is intuitively appealing to posit that a well organized demand-based production strategy will function well under any market conditions, although it is especially cost effective in tight markets. Using the system to simulate alternative supply planning strategies in accordance with projected economic circumstances further contributes to its usefulness in diverse market situations.

American Management Systems, Inc., a management consulting and systems development firm, has developed the Brownboard Order And Rollstock Distribution System (BOARDS) for the Shipping Container and Containerboard Marketing Division of Weyerhaeuser, a company principally engaged in the manufacture, distribution, and sale of forest products. BOARDS provides information services for all phases of containerboard logistics management activity: operational control, management control, and strategic planning. The functions of BOARDS map well into the Framework for Management Information Systems developed by Gorry and Scott Morton (Gorry and Scott Morton 1971) from Anthony's taxonomy of management activity (Anthony 1965) and Simon's continuum of managements' approach to decision-making (Simon 1960). Figure 1 shows the array of decision-making activity supported by BOARDS within this framework.

To the extent that BOARDS handles routine processing needs (e.g., order entry, inquiry and update, and inventory control) it is a conventional management information system. These functions are structured in the sense that they are based upon well understood, easily automated processes and require limited human intervention. The rest of BOARDS supports decision-making that is much less mechanical. Order sourcing, mill scheduling, box shop inventory replenishment and demand/supply planning are examples of functions that require relevant information to be processed and acted upon differently depending upon conditions that are so dynamic and diverse that they cannot be effectively automated. In these cases, BOARDS is designed to assist the decision-maker by providing rapid access to timely information in the format most appropriate to the situation at hand. As the first two columns in Figure 1 depict, some BOARDS functions assist institutional decision-making; i.e., decision-making required to manage everyday business situations. Conversely, some BOARDS functions aid in ad-hoc decision-making as shown in the third column of Figure 1 (Donovan and Madnick 1977). BOARDS is, therefore, more than a conventional management information system and is appropriately termed a Decision Support System (Keen and Scott Morton 1977).

BOARDS OVERVIEW

The distribution of containerboard is illustrated as a cyclical flow in Figure 2. Contemporary containerboard distribution systems are driven by mill production and containerboard supply capabilities. With BOARDS, however, the cycle starts with consumption forecasts provided by the box shops. This input is based upon actual sales agreements, outstanding orders, seasonal trends, and prevailing market conditions. Containerboard Logistics (C/L) management has the option of scaling forecasts up or down, either across all box shops and products or by individual box shop, based upon its

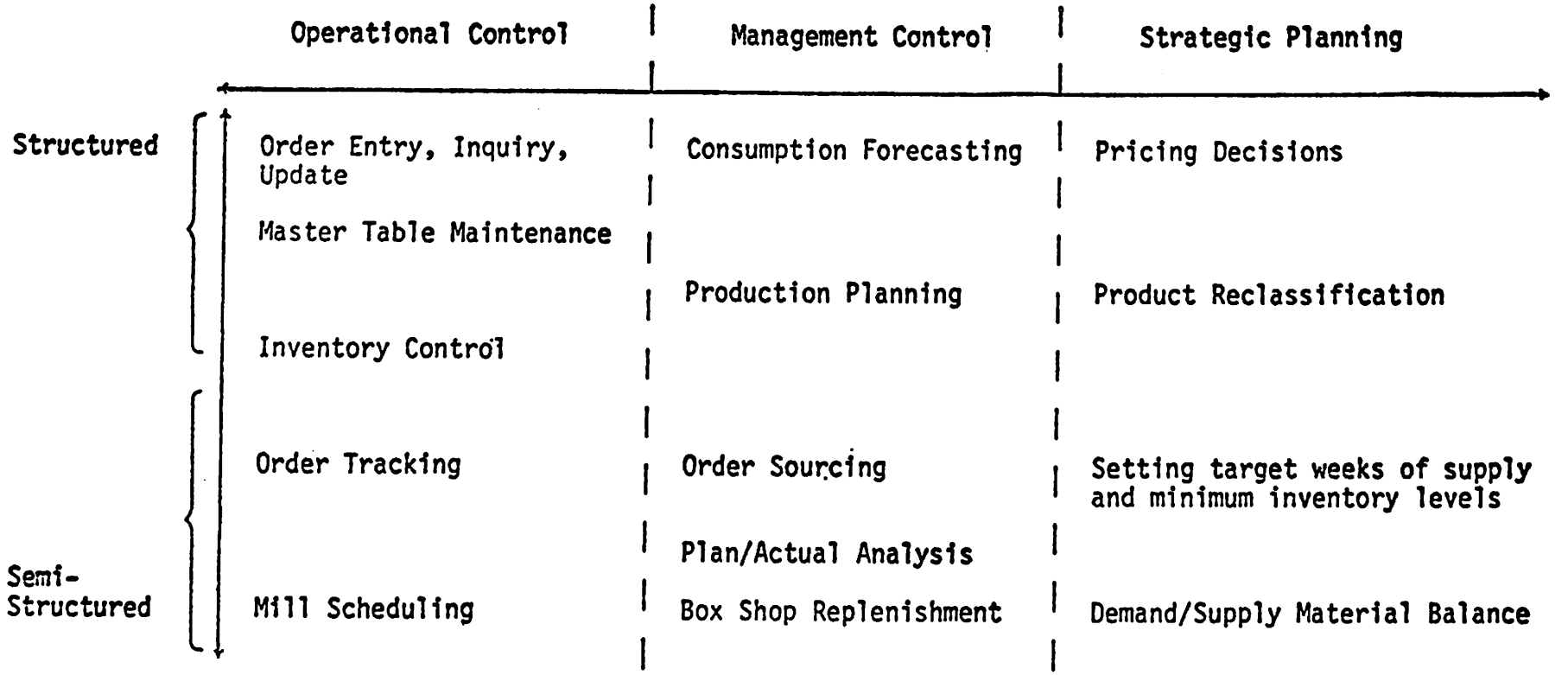

Figure 1

BOARDS-supported Decision Making Activity

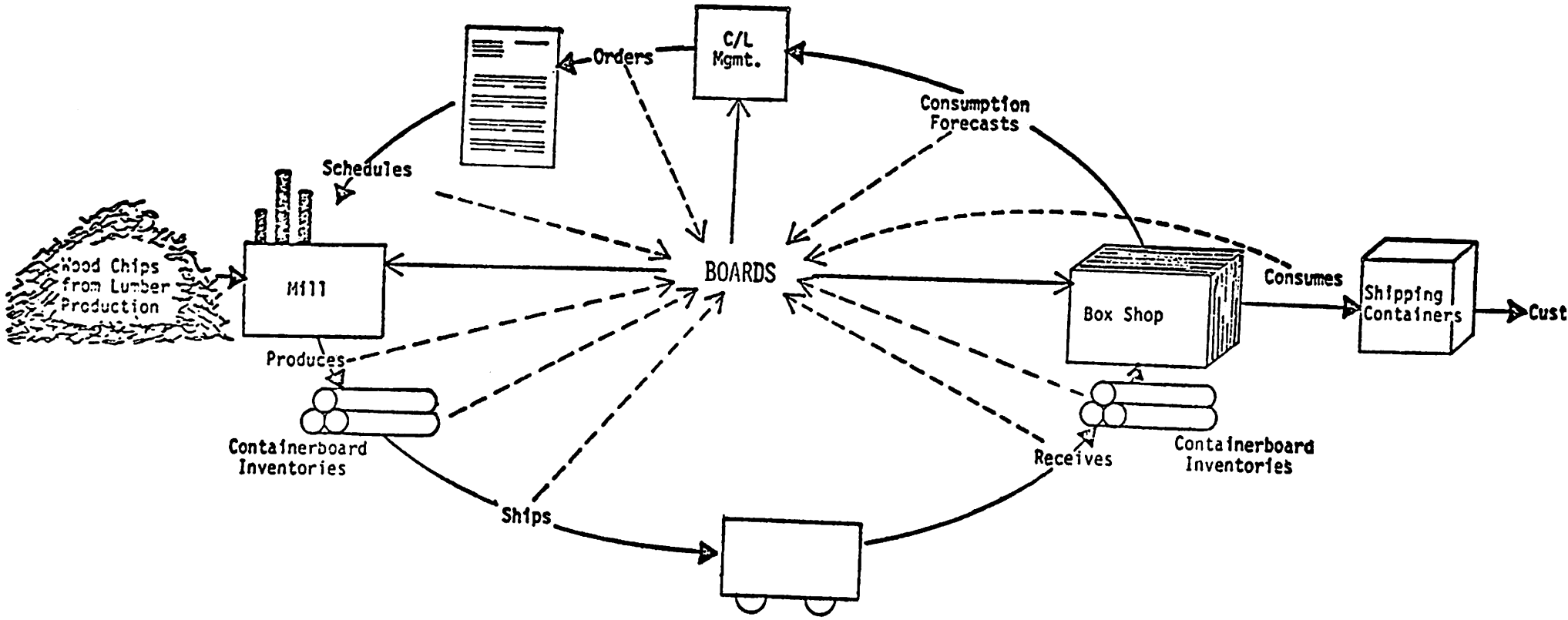

Figure 2
Containerboard Distribution System
and Information Flow

perception of market trends and prevailing or projected economic circumstances. Based upon these forecasts, and knowledge of unfilled orders and current inventory levels, C/L generates mill orders for containerboard. Taking into account current mill production schedules, in-transit times, and production capacities, these orders are then sourced and scheduled at the mills. Mills produce what is ordered, accumulating inventories until shipments are made. The containerboard is then in-transit until it is received by the box shop where it is stored and utlimately consumed.

BOARDS serves two fundamental purposes in this distribution cycle, also shown in Figure 2. Each activity in the cycle is recorded by BOARDS as it compiles a reservoir of information and assists in reconciling operational discrepancies. Correspondingly, BOARDS is a source of information. The mills may examine their production backlog, and the box shops can determine how much brownboard is in-transit, how much is yet to be scheduled, and so forth. C/L may request aggregate or detailed information concerning the current status of containerboard flowing through the system.

BOARDS operates on a dedicated Hewlett-Packard 3000 series II computer with 512K bytes of main memory. Nine distinct IMAGE (Hewlett-Packard's data base management system) data bases constitute the system's foundation. Over one hundred BOARDS functions are aggregated into six integrated subsystems: Order Processing, Production Planning and Mill Scheduling, Inventory Control, Trade Tracking, Planning and Material Balance, and Mill Price Difference Reporting as depicted in Figure 3. BOARDS supports management decision-making at Weyerhaeuser headquarters in Federal Way, Washington, and at 31 box shops and four mills located across the country. BOARDS has added flexibility since it interfaces directly with various computer systems located at the four mills and indirectly via magnetic tape transfer with existing computer systems running on Honeywell equipment at company headquarters. Figure 4 shows an overview of BOARDS hardware configuration and telecommunications network.

A detailed example of two integrated BOARDS functions, Box Shop Replenishment and Mill Scheduling, illustrates the system's potential to monitor and control demand-based production.

BOX SHOP REPLENISHMENT

The Box Shop Replenishment (BOXREP) function, as shown in Figure 5, retrieves weekly consumption forecasts from the Planning Data Base, current on-hand and in-transit quantities from the Inventory Data Base, and outstanding orders from the Order Master Data Base. This data is used to automatically determine the grade and quantity of containerboard to order for each Box Shop in the upcoming weeks. The C/L Box Shop Service Representative interactively specifies input parameters which include whether to use economic adjustment factors that account for recent changes in the market, whether to use target or minimum inventory levels, and report specifications. In-transit times between the mills and the box shops are also used in computing order quantities and shipment dates. Default parameters are supplied from the BOARDS Master Table Data Base upon user request. The results of the computations are stored on the Want-to-Ship Data Base. Quantities stored in this data base represent the amount of containerboard that should be placed on order by box shop and week for the next six weeks in order to meet projected consumer demand.

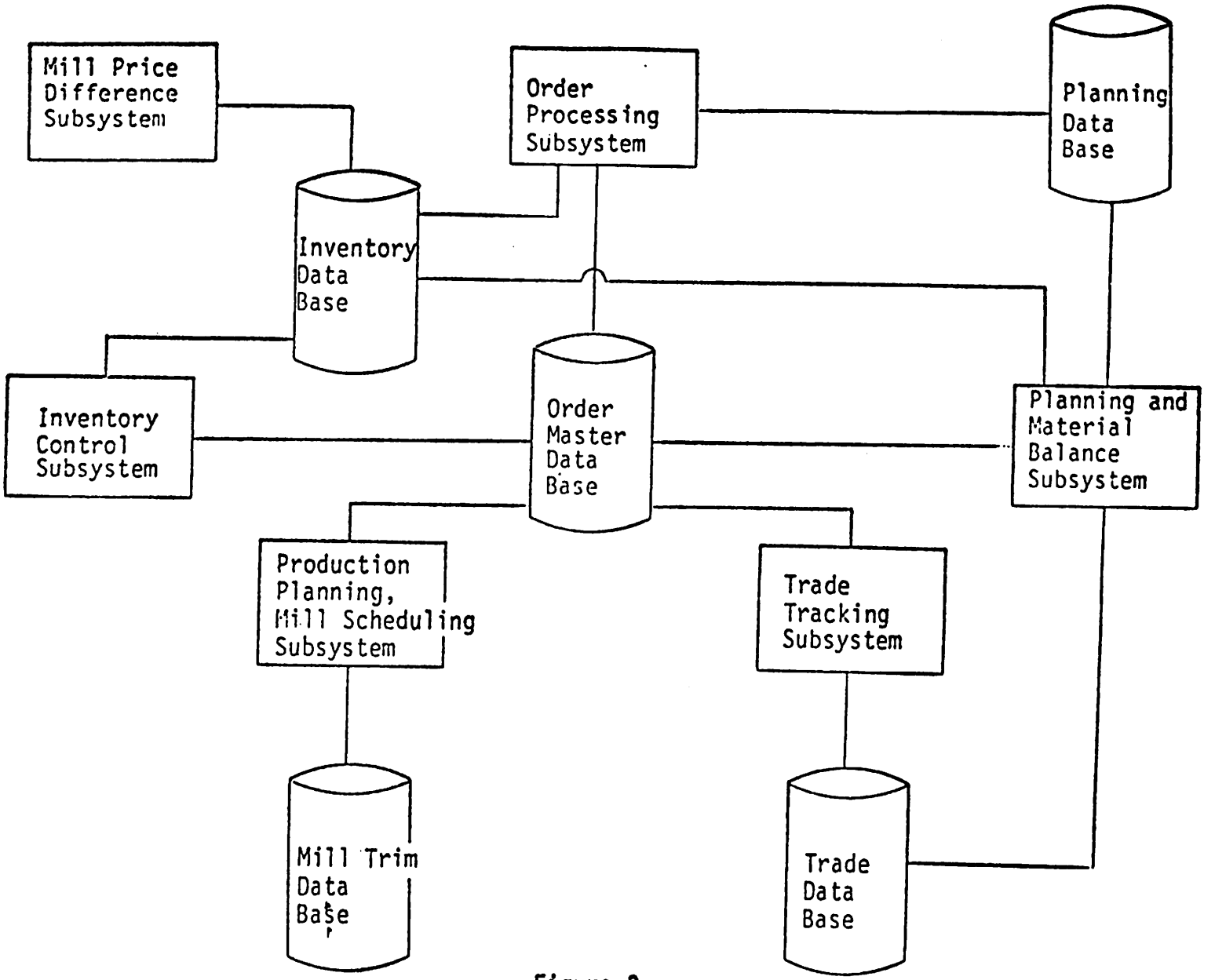

Figure 3

BOARDS Subsystems and Data Bases

(four auxiliary and system data bases not shown)

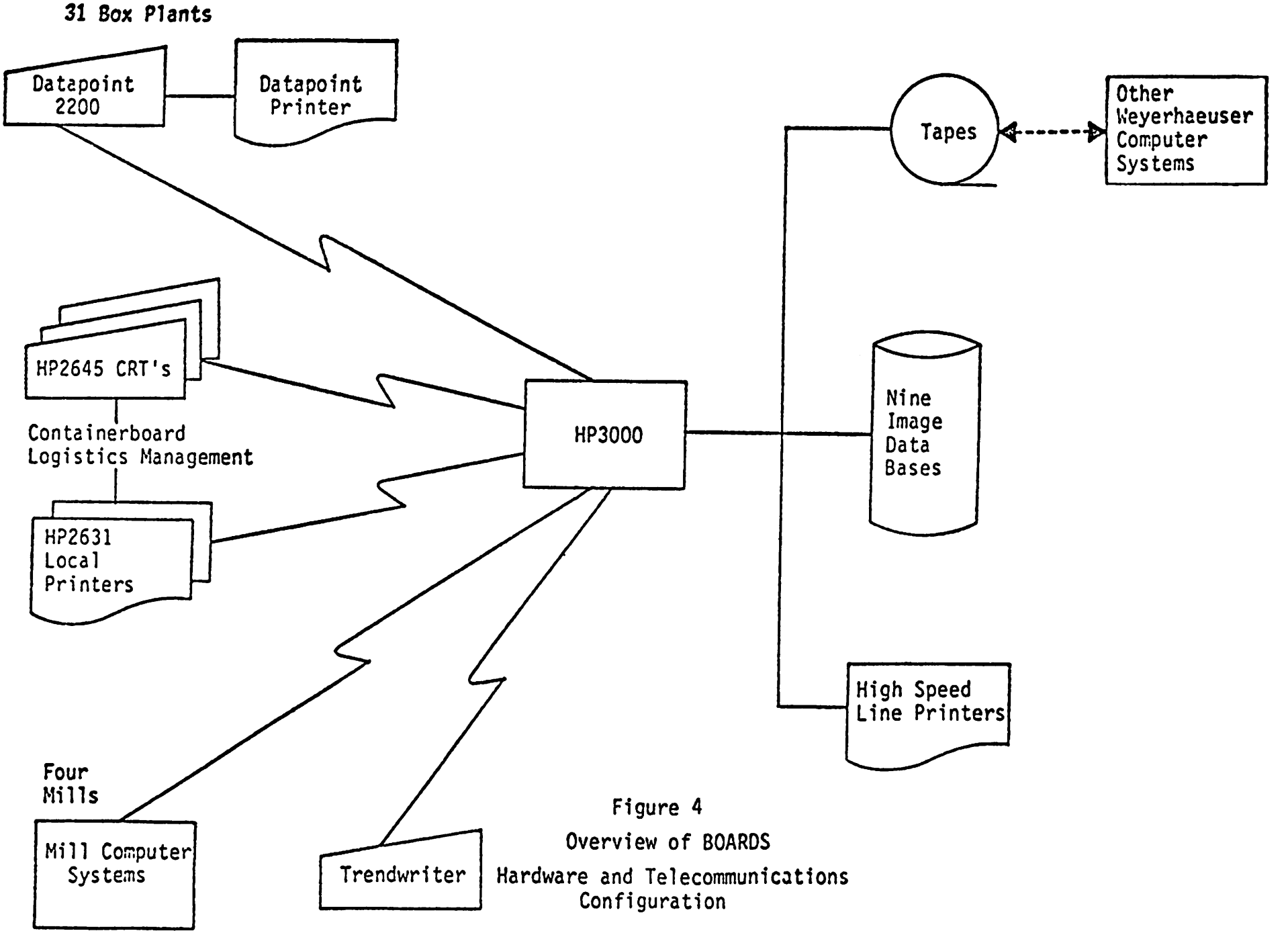

Figure 4

Overview of BOARDS

Hardware and Telecommunications Configuration

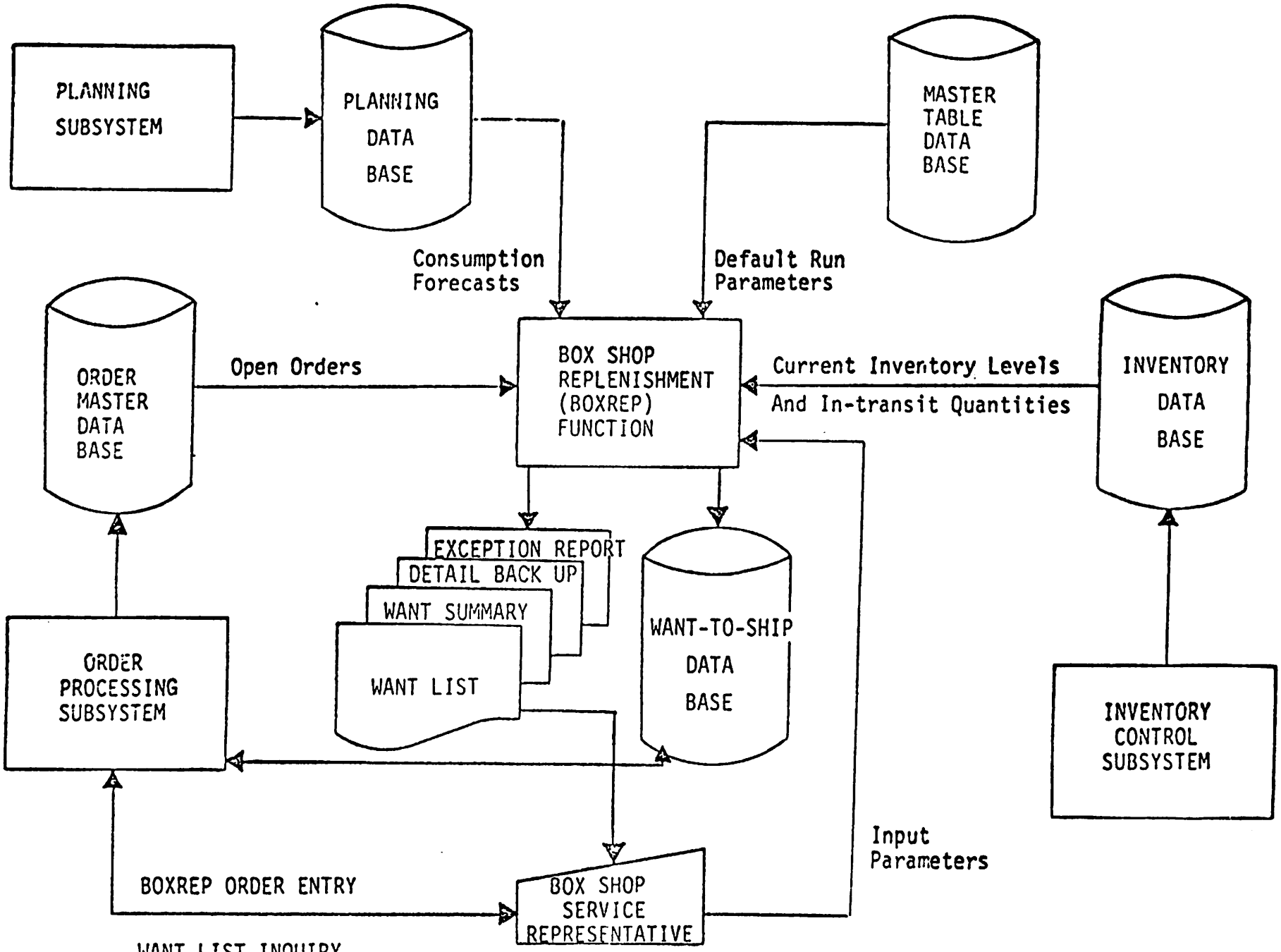

Figure 5

BOX SHOP REPLENISHMENT FUNCTION

BOXREP results can be examined in any of three ways. The first output is in the form of standard reports. The reports show Want-to-Ship quantities in varying levels of detail and aggregation. BOXREP also produces an exception report that shows current and projected crisis conditions by week for each box shop and product (for example; inventory levels are projected to fall below minimum, or expected receipts are greater than capacity). The second mechanism for inspecting Want-to-Ship quantities shows a box shop's proposed shipments in the form of a purchase order on a CRT. The information is displayed, can be revised and, optionally, converted into an open purchase order. The quantities stored on the Want-to-Ship Data Base are automatically adjusted to account for containerboard that is placed on order. Lastly, C/L management or users at the box shops can examine the current contents of the Want-to-Ship Data Base. A BOARDS inquiry function interactively displays the proposed shipment quantities by box shop, product and ship week, adjusted for orders already placed.

Proposed shipments are never automatically converted to open orders, since many non-quantifiable factors affect the decision to place an order. Surrounding economic conditions can drastically alter the usefulness of proposed shipments. Therefore, manual involvement is critical. Support for this sort of semi-structured decision-making is what distinguishes BOARDS from conventional management information systems. The utility of BOXREP is in assisting order generation rather than in automating it.

While BOXREP is engaged in information retrieval, calculations and reporting, the user is free to execute other BOARDS functions since the BOXREP processing is performed in batch mode. BOXREP can also be run iteratively to test the impact of alternate consumption and inventory adjustment factors, policy variables or target inventory levels without interfering with the active contents of the Want-to-Ship Data Base. When a desirable set of calculations has been achieved the data base can then be updated. BOXREP logic is configured such that several BOXREP processes can be under way simultaneously as long as only one is updating the data base. This flexibility has been provided to enhance BOXREP's utility as a planning facility in addition to its use as a production system.

MILL SCHEDULING

Mill scheduling, as shown in Figure 6, consists of three functions: Trim Input, Trimming, and Mill Order Maintenance. Containerboard Logistics' mill schedulers use these functions to specify the quantity, sequence, and date in which ordered containerboard is to be produced at each mill. Their objectives are to maximize production efficiency and minimize trimming loss. The scheduler uses the Trim Input function to interactively select unscheduled purchase orders from the Order Master Data Base for production at the mills. The retrieved orders are displayed on a CRT as a "Trim Input". The scheduler can modify the input as desired to obtain a tentative set of orders to be scheduled together at a mill. Once satisfied with the Trim Input, the scheduler specifies a trim algorithm, either the linear programming

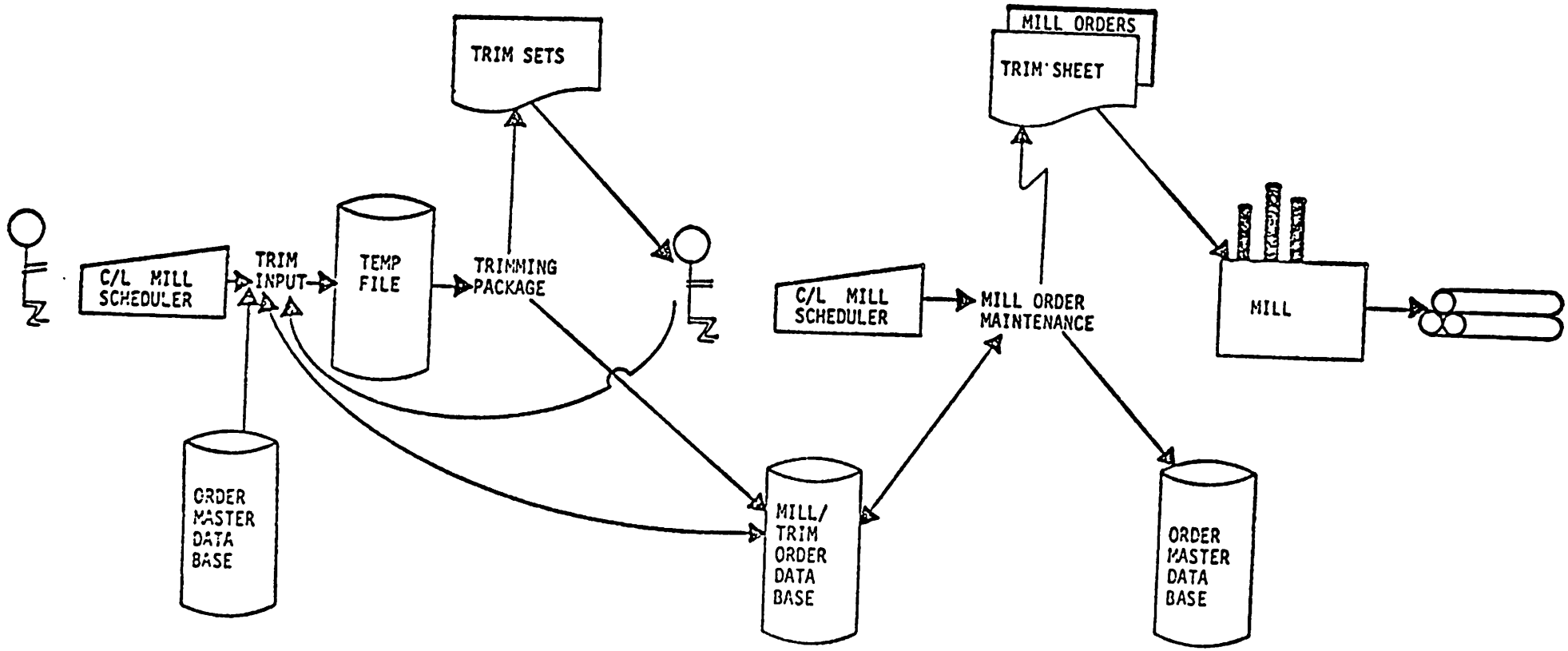

Figure 6
BOARDS MILL SCHEDULING

model or the heuristic program, and the Trim Input is passed to the Trimming function via a temporary file. The Trimming function executes the selected trim algorithm, stores the results in the Mill/Trim Order Data Base, and prints the results, referred to as a Trim Set. The Trim Set shows the near optimum positions in which to place cutting knives in order to trim the maximum number of ordered widths per containerboard roll and minimize the trim loss.

The Mill Order Maintenance function converts a Trim Set into a Mill Order. If the Trim Set is satisfactory, the scheduler can interactively convert it by assigning a production date and sequence number, and requesting that the production schedule be forwarded automatically to the mill. Alternatively, the scheduler can manually adjust the Trim Set to account for factors not considered by the trim algorithm. Lastly, the scheduler can discard the Trim Set altogether. In this case, the scheduler either modifies the original selection criteria or compiles an entirely new set of criteria to construct a new Trim Input and begin the trim cycle again. Note, once more, the critical role of human involvement in BOARDS supported decision-making. The scheduler is better prepared than a totally automated process to deal with day-to-day peculiarities and priorities. Therefore, the Trim Set is never automatically converted into a Mill Order.

It may require several iterations before the scheduler arrives at a satisfactory production schedule. Although the objectives are well defined, it is technically infeasible to completely automate the scheduling process. BOARDS provides utility in that it enables several input combinations to be analyzed in the form of production schedules. The limiting factor is time. To examine every possible set of input combinations is tedious, time consuming, and costly. BOARDS facilitates this complicated decision-making process by enabling more alternatives to be considered through functions that are efficient, fast, and easy to use.

CONCLUSION

BOARDS provides decision support in all phases of containerboard logistics management: operational control, management control, and strategic planning. BOARDS is distinguished from conventional management information systems in that it integrates automated processes of management science and operations research with routine data processing and human decision-making. Advanced technologies, in the form of data base management and distributed on-line user access, are brought together to form a system that satisfies the long term information processing needs of Weyerhaeuser's containerboard logistics management. Its goal is to control containerboard inventories and to improve inventory distribution by supporting demand-based production planning in an industry highly sensitive to market conditions and economic circumstances.

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