INTEGRATING PLANNING AND EXECUTION THROUGH CONTEMPORARY HANDLING SYSTEMS

John M. Hill, Logisticon, Inc.

Dramatic changes have occurred in the US material handling market since 1979. These changes are due in large part to a broader understanding within the user community of the impact of material handling throughout manufacturing, warehousing and distribution. The relative size of the large scale automated storage system market has diminished in the past five years with the trend toward lower inventories and "just-in-time" delivery. Users and suppliers now think in terms of modular systems that link such tools of automation as guided vehicles, carousels and transporters in smaller configurations that are more adaptable to changing business conditions and product mix. Further, recognizing that increased throughput, tighter inventory control and lower per unit handling costs are keys to survival, conventional warehouses as well as manufacturing stores operations in the US are adopting new PACKAGED information and control systems that can be installed, modified and expanded quickly and less expensively.

Background

The most significant development in the United States material handling market in the past fifteen years is user recognition of improved inventory control as a tangible basis for handling system investment. Control of raw materials, work-in process and finished goods inventories from warehouse receipt to customer shipment is fundamental to effective operations management in any industry — in any country. Tighter stock control leads to faster order turnaround, improved use of people, facilities and equipment, lower inventory investment, and reduced costs.

The foregoing is not a new perspective; nor is inventory management of new concept. What has changed in the past few years, however, is American industry's understanding of the impact of improved inventory management on corporate profitability — the growing evidence that the impact can be quantified — and that material handling can play a critical role in the equation. Although handling systems suppliers, academicians and consultants have agreed on this point for years, the majority of US investment in these systems has been justified on the basis of space and labor savings alone. Why is the pattern changing?

Knowledgeable US managers have recognised for some time that material handling represents from 30% to 80% of typical operating costs. Until recently, however, handling had been viewed as an unavoidable adjunct to value-adding processes — a necessary evil that all too frequently took last place on the capital budget priority list. This perception was inadvertently reinforced in the late 1970's with the flood of reports in the trade and business press on declining US productivity. Articles focused almost exclusively on the manufacturing sector, its aging facilities, outmoded machinery and techniques, and a de-motivated US workforce. An average annual productivity growth rate of .4% during the 1970's supported the concern. Indeed, during the same period, US warehousing productivity averaged (.5%). While some talked of the inevitability of continued erosion of the United States' industrial base, others set out to find solutions.

Next, we heard glowing reports from overseas about KANBAN, JUST-IN-TIME and the AUTOMATIC FACTORY which promised:

"an unmanned, unlighted, marginally-heated plant that devours raw materials delivered moments before they are needed and converts them into finished products which are immediately loaded for customer shipment."

With the help of Hollywood, "reprogrammable, multi-function manipulators" or robots soon joined the list of solutions. And, of course, everyone had to have one. From the data processing sector, material requirements planning or MRP emerged as the answer for the inventory control portion of the equation; and many companies plunged forward with adoption, ill-prepared for the costs associated with faulty implementation, inaccurate forecasts, production miscues, day-, week- or month old reports, etc.

During this period, little press was given to the potential contribution of material handling systems except for the more exotic applications of guided vehicles and the massive AS/RS installations of the mid-seventies. Similarly, the concept of integrated systems, though intellectually within grasp, was infrequently emphasised as a fundamental goal for productivity improvement programmes. The three-year period from 1980 to the end of 1982 was a difficult one for a good portion of American industry. Budgets for capital expenditures were particularly tight and payback criteria stringent. During this period, US material handling equipment sales dropped more than 40% (from approximately $10 billion to under $6 billion). At the same time, however, robotic equipment sales grew from under $50 million to $190 million and MRP sales exploded to cover over 3000 systems with a total value of $1.35 billion. The statistics support my contention that, in the rush to turn the corner on declining productivity, many users looked to specific pieces of value adding equipment or batch oriented, not real-time, data processing systems, i.e., piecemeal solutions that addressed part, not all, of the problem.

The result? Isolated islands of automation and/or output from data processing too old to be useful for real-time management of actual operations. I do not mean to suggest that managers were unaware of the benefits of integration of a fuller complement of equipment and systems, but, rather, that limited budgets and narrowly focused payback criteriam forced them to allocate funds to those areas where apparent savings could be more readily identified. As these partial solutions were implemented, it became clear that:

- *Although initial attempts at solving the productivity* problem may have produced marginal returns, the time-worn alternatives of "more inventory" or "more people" — even if economically feasible — were simply no longer acceptable;
- No MRP system can deliver the expected benefits without real-time visibility of actual transactions at receiving, in storage, in production and at the shipping dock;
- No amount of equipment or systems can obscure omission of the fundamentals of materials management in the development of any industrial automation project;
- The value of increased throughput on production machinery is a direct function of the adequacy of the delivery system that supports it;
- Flexibility, integration and control would be the cornerstones of future systems designed to meet the

needs of fast-moving manufacturers in an increasingly competitive world market.

With a better appreciation of the foregoing, both the press and users began to talk in terms of computer-integrated manufacturing (CIM), flexible manufacturing systems (FMS) and, more recently, computer-integrated logistics (CIL) and flexible material management (FMM). In each case, flexibility, integration and control provide the framework for the particular technologies which form the discipline — and material handling plays an increasingly prominent role by providing the disciplined environment critical to effective implementation of the integrated system.

In the following pages, the impact of this shift in perspective upon various segments of the US material handling industry will be examined. As a baseline, it should be noted that industry sales have rebounded from the 1982 low point, growing some 40% since that time, but with a considerably different composition. As painful as the 1980-82 period was for the typical supplier, the opportunities for those survivors and newcomers who have adapted their products for contemporary integrated manufacturing systems have never been greater. Indeed, the installed base of major automated handling systems in the factory is expected to grow from 700 in 1984 to 5805 in 1990, a compound annual growth rate of 58.2%. Further, these developments have positive implications for those charged with warehousing and distributing raw materials and finished products to and from not only the "just-in-time" manufacturer, but also all of those manufacturers who recognise the bottom-line value of the concept.

MH Systems Focus: Discipline

Trends toward shorter production runs, lower inventory levels and "doing the job right the first time" preclude operations management on the basis of historical performance reports. Given realistic productivity, product quality and customer service goals, the difference between success and shortfall will be heavily influenced by:

- The administrative discipline provided by the systems and procedures used for order processing, production planning, purchasing and related corporate functions;
- The process discipline provided by computer-aided design, computer-aided engineering, statistical process control and other subsystems and equipment that target upon lower cost, higher quality production;
- The material management discipline provided by the handling system which receives, moves, stores and controls "assets in process" throughout the entire operation;
- The accuracy and timeliness of information exchange between the handling, process and administrative disciplines — AND, the speed and quality of response to anomalies, exceptions and opportunities for improved performance.

Material handling equipment and system developments in the past few years have been highlighted by enhancements that not only improve control of physical material flow, but also managements visibility of real-time operations. Developments fall into one or more of the following areas:

- IDENTIFICATION: Bar code, RF, machine vision, radio data terminals
- MOVEMENT: Conveyors, guided vehicles, lift trucks, robotics
- STORAGE: AS/RS, mini-load, carousel, tote stacker
- CONTROLS: Sensors, computers, programmable controllers, packaged and custom software

Of particular significance is the attention given to the three driving forces mentioned earlier: flexibility, integration and control. Equipment modularity and the thrust toward standardisation are also characteristics of the new family of systems and equipment. The following paragraphs highlight some of these trends.

Identification

Bar Code

Few technologies have had as long a gestation period as automatic identification. About the same time Wiley Post made his solo flight around the world (1933), initial patents covering the use of optical sensors for automatic package sortation were issued in Switzerland. For the next thirty years, the primary focus of identification technology was in the area of direct machine control — from conveyor line sorting to automatic bobbin replenishment in textile mills. In the early 1960's, pioneering efforts associated with optical systems for railcar identification and automatic check-out at grocery supermarkets suggested the information potential of such systems for item tracking in factories, warehouses and distribution centers. Initial applications of these early code reading systems in industry (Volkeswagon, 1969 and General Motors, 1971) were justified solely on the basis of labour savings associated with production counting — NOT the value of increased inventory accuracy — and usage grew slowly. A second constraint on growth was supplier reluctance to collaborate on code or symbol standards for industrial applications. The situation began to change in the late 1970's with user-initiated pressure for standards. Today, formal standards have been promulgated by the US Department of Defense, the American National Standards Institute and such industry organizations as the Automotive Industry Action Group, the Health Industry Bar Code Council, the National Association of Wholesaler Distributors, etc. The standards include specifications for the alpha-numeric "Three of Nine" code and the numeric "Interleaved Two of Five" code. It is estimated that the industrial market for these systems is now growing at a better than 30% annual rate with industry associations, user groups, seminars, shows and conferences adding fuel to the fire. Primary developments in the bar code area include:

- Auto-discrimination: the ability of decoding electronics to automatically recognize, read and verify multiple symbol formats;
- Handheld Laser Scanners: light weight, non-contact portable code readers that provide greater operator flexibility;
- Omni-directional Laser Scanners: fixed-position readers capable of reading a code regardless of its orientation;
- Expanded coding capabilities: from computer-controlled dot-matrix printers to laser-etching for printed circuit boards and castings when standard printing or labeling cannot survive the process environment.

Other Identification Technology

The growth of bar code reading systems as important tools for productivity improvement has rekindled interest in a variety of non-optical techniques for automatic and operator-driven real-time data entry including radio frequency, surface acoustical wave, magnetic stripe and voice recognition systems as well as mobile radio data terminals. Further, in concert with the growth of robotics, machine vision is rapidly emerging as a potential alternative for a number of applications.

Identification systems are a vital element in the mix of solutions available for improved factory and warehouse productivity. As such and in that they provide the window for management on operational performance, their careful consideration in the early stages of design can make significant contributions to operational control and system integrity.

Movement

The variety of alternatives available for moving materials could fill a library. Our focus in the following paragraphs will be on those developments that bear directly upon providing users with tighter control of inventories, flexibility and the potential for more fully integrated systems.

- **Lift Trucks:** Lift truck sales in the U.S. have not recovered from their plunge from 109,000 units in 1979 to 62,000 units in 1982. Although considerable press has been given to the encroachment of overseas competition, the fact is that users are now turning to other means of horizontal transportation. To meet the challenge, U.S. manufacturers are adding:
  - Two-way mobile Radio Data Terminals (RDTs) is that permit computer-controlled dispatching and operator performance monitoring;
  - On-board controllers that permit automatic height positioning and other features that allow integration of conventional operations with computer-based systems.

  Given these enhancements and the demands for flexibility, we see a continuing significant role for narrow-aisle vehicles that present a cost-effective alternative to aisle-captive automated storage and retrieval systems. Further, these enhancements offer current users the opportunity to upgrade existing operations without major new capital outlays.

- **Automatic Guided Vehicles:** The AGV market in the US is currently growing at a 30% annual rate after more than twenty years of relatively modest growth. Primary reasons include AGV flexibility and the relative simplicity of its integration with computer-based systems. Trends highlighted in a recent report include:
  - Growing use of AGVs as mobile work platforms that carry work to various assembly stations;
  - Fork-equipped vehicles that lift and stack loads to various heights;
  - Special-purpose designs for applications in specific industries; e.g. newsprint handling, "clean room" handling in disk drive and semiconductor production;
  - Other designs that integrate on-board robots, manipulators, conveyors, turntables and other devices to fit the user's particular requirement.
  - Significant improvement in the cost and reliability of control software including user-friendly routines that minimize the complexity of guidepath or vehicle routing changes.

  We also expect to see increasing progress on off-the-guidepath travel and related installation cost reduction. Accordingly, there's little question of continuing growth for AGVs as flexible alternatives to fixed path systems.

- **Conveyors:** Flexibility, integration and control have been the watchwords for US conveyor industry development of new family of modular systems to support kitting and small parts assembly in the electronics and other industries. These systems — often called transporters — are characterized by:
  - Chain or belt drive bi-directional transport conveyors;
  - Micro-processor controlled, single or double air-transfers that can be easily moved or interchanged;
  - Preassembled modules (i.e. beds, transfers and workstations delivered with integral air, electrical and communications lines) to speed installation and simplify maintenance as well as adaptation for new requirements;
  - Low noise level and "clean room" compatibility;
  - Direct communication with operator work-stations and user host computers.

  The integration of these systems with contemporary small parts storage systems has led to significant improvement in throughput control, inventory reduction and space utilization for such companies as Priam (disc drive manufacturer), Westinghouse and others.

Storage

While the trend towards just-in-time delivery has lessened demand for large scale automated storage systems in the manufacturing sector, it has also fostered growth and innovation in other storage system approaches including mini-load, micro-load, tote stackers and vertical and horizontal carousels. Further, demand for unit load systems for finished goods warehousing has held fairly constant and computer control has found a niche in conventional flow rack picking systems. Let's briefly review some of the more significant trends.

- **Unit Load AS/RS:** Primary developments in this area are those associated with optimisation of throughput or transaction rates through simulation and software that maximises productivity on the basis of operation-specific requirements; e.g. first-on, last-off trailer loading, etc. There is also a move towards upgrading or retrofitting older storage systems with contemporary software, automatic identification equipment and interfaces with automatic guided vehicle subsystems.
- **Mini-loads, Micro-Loads and Tote Stackers:** With smaller inventories, parts and kit control for manufacturing operations has never been more critical. Primary users in the United States today are the automotive, airline and electronics industries although appliance manufacturers, parts distributors and others are showing increased interest. Current trends include:
  - Increased reliability: 97% uptime and six to seven years before major overhaul is normally required.
  - Lateral as well as end-of-aisle input/output stations for assembly operations;
  - Lower software costs with increased focus upon "velocity loading" and higher transaction rates;
  - Standardisation or "pre-engineered" hardware and software modules targeted at reducing costs and delivery time;
  - Designs that are somewhat easier to relocate than earlier versions.
- Carousels: Often characterized as "the poor man's AS/RS", vertical and horizontal carousels are quickly becoming an important element in integrated systems. In fact, in a recent survey of some thirty applications where mini-load or carousels could have been used, the carousel generally offered a higher return-on-investment. Like the competitive alternatives, carousels offer significant productivity improvement potential by bringing the "pick location" to the worker. Combining carousels with transporters, robotic loaders and unloaders and other devices offers not only faster, more efficient material flow to kitting and production, but also the tighter stock control that permits

reduction of inventory.

Other features that assure carousels of a continuing role in contemporary manufacturing and distribution include:

1. Low maintenance costs — often as little as .1% of the unit's original cost per year;
2. Modularity and flexibility — systems can be installed, relocated and expanded (through module additions) more readily than other AS/RS;
3. The appearance of innovative designs such as the horizontal carousels whose tiers move independently for increased throughput;
4. Continued developments in basic controls, interfaces and standard software.

Controls

The evolution of controls for material handling and material management applications in the past few years has been mind boggling. In addition to refinement of sensors, motor starters, communication links, etc. for direct machine control, the advances in computer hardware and software have been significant; and, their role in future systems solidly assured. Indeed, the demand for automated handling systems mentioned earlier is expected to produce the following results for suppliers of programmable logic controllers and mini-computers:

Installed Units	1984	1990
AMH Systems	700	5805
Prog. Controllers	5531	29438
Mini-Computers	1000	7508

Given the foregoing, there is little doubt that the growth of automated handling systems is intimately linked with the growth of real-time information systems in the plant or warehouse environment.

As impressive as the projections may be, however, there is one other important consideration. The installed base of MRP Systems in the United States is expected to grow from about 21,000 to over 143,000 units. Although an over simplification, one could come to the conclusion that by 1990 well over 100,000 MRP users will be managing their inventories without the discipline provided by an integrated, computer-controlled handling system or the benefits of real-time feedback such a system can provide. This conclusion ignores the probability of installation of identification subsystems, radio data terminals, etc. in conventional facilities for inventory transaction monitoring, but even if the numbers are discounted by 50%, it highlights the fact that user awareness of the benefits of integrated systems is still in its infancy.

Part of the problem has been the apparent simplicity of batch-oriented MRP Systems and their implementation. As experienced practitioners have learned, the converse is more frequently true. Further, MRP may not be the best solution for every company — (consider its utility for companies with new products with undefined demand) — BUT, *material control certainly is!*

THE PRIMARY DISTINCTION BETWEEN BATCH-ORIENTED SYSTEMS AND REAL-TIME SYSTEMS IS THAT THE FORMER EMPHASIZE PLANNING AND STOREKEEPING, WHILE THE LATTER FOCUS UPON EXECUTION AND WINNING THE GAME.

Effective material control depends upon the accuracy and timeliness of information exchange at and between the corporate hierarchy. In the absence of standards for such exchange, it is not difficult to understand the appeal of early MRP systems which ran on existing and familiar data processing hardware and provided more useful output than had been previously available. Constraints on the growth of integrated, real-time material control systems have included:

- Computer hardware capacity and cost;
- Incompatible communications interfaces, protocols and standards;
- Resistance from corporate data processing personnel who were persuaded that batch approaches were sufficient;
- Lack of top management support;
- Myopic payback criteria.

Further, early attempts at implementing integrated material control systems were hampered by:

- The cost, complexity and delays associated with custom real-time software development;
- Problems with systems that combined machine control and inventory management on undersized computers with low transaction processing speed; and,
- Little system flexibility to accommodate changes in product mix, scheduling, routing, etc.

No one denies that the availability of flexible standard software packages for real-time material control will substantially reduce the risks and accelerate adoption. Indeed, such packages are fundamental to extension of the benefits of this control beyond the limited set of larger companies now enjoying them. Given a family of modules from which a user can select those features that address his particular needs, we should expect to see a dramatic increase in integrated systems usage for years to come.

The practical challenge to standard package development has been definition of and agreement upon the basic functions that such packages should include and, then, the optional features that would extend their utility to a broader group of prospective users. Given the availability of such packages, the next issue is user willingness to unemotionally assess the trade-offs between a packaged system that may address 80% to 90% of his requirements and the custom alternative, tailored just for him, but at substantially higher cost. Considerable progress has been made on both fronts in the past couple of years. Let's take a look at a couple of these systems:

- **Conventional Warehouse Systems:** The genesis of packaged real-time material control software was in the conventional warehouse. A primary reason for this was that such a system could provide measurable benefits on its own without the need for direct linkage to a corporate host computer. Orders and shipping instructions were manually entered and operations summary reports printed on site for subsequent transfer to corporate management.

  The focus of these systems is upon tracking materials from receipt to storage, stock location record maintenance, pick generation and inventory adjustment upon shipment. In the conventional facility, communications with supervisory personnel are generally via printers and CRTs, and with order pickers via hand-held or lift truck-mounted radio data terminals (RDTs). Most of the systems being installed today do have a batch or real-time communications link to the user's host computer.

In operation, the systems accept orders from the host while stock receipts are entered via CRTs at receiving. The systems organise daily activities and allocate work on the basis of demand and available resources. Operators receive tasks via RDT to store, move or pick materials. They confirm completion of each task before the systems will assign the next activity. Inventory files are updated by item and location upon completion of each transaction. Reports are generated routinely and on demand for supervisory personnel. All transactions are recorded on an inventory transaction log which is periodically transferred to the host.

Other features of these systems include:

- System or operator selection of storage location;
- Shipment planning;
- Item reservation/quarantine;
- Batch or single order picking;
- Kit picking;
- Stock relocation;
- Forward pick area replenishment;
- Cycle counting;
- Backorder and crossdock handling;
- Lot control;
- Productivity analysis.

System benefits include the ability to interleave material storage, picking, replenishment and inventory checking on a single lift truck cycle, thereby eliminating deadheading and increasing operator and vehicle productivity. Reductions of better than 30-40% are not uncommon. The elimination of paperwork and increased inventory accuracy are also cited as primary sources of payback. The modular construction of the systems permits the addition of both software features and hardware to meet expanding requirements with minimal disruption of operations. Further, most systems permit the user to generate additional reports peculiar to his specific requirements. Initial installations of these systems suggest potential cost savings of 30-40% when compared with custom alternatives and delivery times are as short as three to four months.

- **Material control systems/Mechanisation & Manufacturing:** In the past year, the functions we've just reviewed have been repackaged for use within the manufacturing environment. As opposed to communicating with lift truck operators via RDT, these systems communicate with the programmable controllers and micro-processors that control the storage and delivery of materials to and from workstations or the assembly line. Characteristics of these systems include the applicable warehouse system functions noted above and:
  - Workorder check-in and release;
  - Workload allocation;
  - Workstation communications and control;
  - Routing optimisation; and,
  - Material handling device control.

  Essentially, these systems provide a real-time bridge between batch-oriented manufacturing planning/MRP and the factory floor. They are not a replacement for MRP, but rather the complement to it that closes the loop on fully-integrated material control.

Conclusions and Caveats

Fifteen years ago at a material handling seminar, a speaker stressed the importance of totally integrated manufacturing and distribution operations, noting that the materials handling system for the future must be able to respond to automatically generated material management commands . . . and, that the response must be fast enough to satisfy the particular requirements of the overall operation. Later, at a packaging show, a plant manager warned that success in automating and speeding material flow had too often been dimmed by the absence of a parallel effort aimed at obtaining real-time information and operation status from the line.

Borrowing a word from the manufacturing sector, I submit that the catch phrase for the next fifteen years and beyond will be FLEXIBLE MATERIAL MANAGEMENT — and, as you have heard, that the tools now exist to profitably manage both information and material flow — for small companies as well as large — for warehouse managers as well s plant superintendents.

Make no mistake, however. These systems are not solutions for inadequacies in requirements analysis or system design; nor are they a substitute for basic discipline in current material or information flow — or slipshod management.

In dealing with control of assets-in-process, objective analysis may point towards full or selective automation — or, in some cases, hardly any automation at all. The issue is simply what combination of people, equipment and systems will provide you with the level of flexibility and control your operation demands. In other words, whether user or supplier, pioneer or apostle, each of us has an obligation to keep an eye on the basics and our feet on the ground in our headlong rush towards the factory or warehouse of the future.

About the author

John M. Hill is chairman of Logisticon, Inc. As 1980 President of the U.S. Material Handling Institute, Inc., he has also served as president of the Material Handling Education Foundation, Inc., an officer of The International Material Management Society and a member of the College Industry Council on Material Handling Education. Logisticon is a California-based developer of real-time material control systems.