by researchers to tailor analytical techniques, such as the diversion analysis described above, to the unique distribution patterns of different industries and geographical regions. Survey techniques need to be developed in two directions: (a) more-economical and expeditious techniques to permit wider market coverage and (b) more-sophisticated, in-depth techniques to better understand the shippers' purchase decisions and to improve the reliability of survey results. Survey techniques and simulations can be complementary if they are developed in tandem. To realize the most value from both, their most-appropriate applications should be identified and linked. A shipper panel, established on a semipermanent basis along the lines of the Nielsen ratings for television, is one way to regularly gauge the impact of changes in shipper perceptions and environment on the purchase decision.

Product differentiation is becoming an increasingly important concern for both carriers and shippers. Costing techniques should be refined to better estimate the production-cost impact of providing different levels of sevice. Carrier costs have been the focus of a considerable amount of attention (perhaps too much). Costing techniques should be developed to better reflect local operating conditions and, more importantly, the perception of carrier management.

In sum, there are several areas that require further exploration for both cost and service and shippers and carriers. Clearly, this research will be most valuable if it reflects the decisions made in the marketplace and is designed to assist decision makers.

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Measuring Intermodal Profitability

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The profitability of intermodal operations provided by the rail industry and commonly known as trailer-on-flatcar (TOFC), or piggyback, service has been questioned in recent years. Although TOFC loadings have increased, the growth has not been as rapid as many believe possible; the industry's hesitancy to make the necessary investment and the reluctance of other modes to take advantage of rail line haul are indications of this situation. Although railroad-costing methodology has improved in the past decade, difficulties still exist in ascertaining profitability of any one segment of traffic. The difficulty of allocating costs prevents costing officials from accurately determining intermodal costs and hence profitability. It is this situation that confronts management with investment decisions and presents the Federal Railroad Administration (FRA) with problems in the promotion of intermodal operations in the rail industry. Congress provided funding for the FRA to partially offset operating losses in intermodal demonstrations under certain criteria; the most important of these are potentially profitable operations. In view of the problem with railroad-costing methodology, how should the profitability be measured? The FRA is funding research in two phases to develop an Intermodal Management Information System (IMIS). The first phase, an overview of rail information systems and a state-of-the art survey, confirmed the need for an IMIS and identified three modules that could be readily transferred to the industry. In various stages of development and testing are an Intermodal Management Equipment Control System (IMECS), which generates adequate records for detention billing and control of trailers, and a Repetitive Waybilling and Rating System (RWRS), which electronically maintains a comprehensive audit trail of waybill activity. Both these systems (and other sources) provide an automated collection of intermodal records to ascertain profitability for the rail carrier.

Since 1973, the ever-worsening fuel crisis and critical environmental problems have dramatized the need for truly efficient transportation. Each mode of transportation has individual characteristics of cost or service that are superior to those of competing modes depending on the distance and the function. When fuel was abundant and transportation modes were economically healthy, inefficiencies were tolerated in the name of laissez-faire competition. However, it has now become essential to encourage the combining of the best features of each mode into a total system; this cannot be accomplished by any one transportation company restricted to a single mode of operation.

In the case of domestic merchandise and perishable commodities, the ultimate solution may be a refinement of truck and rail piggyback service. This basic concept dates back many years and its use has been growing, but at a rate far slower than the true potential would justify. Investigation has disclosed numerous problem areas that impede the expansion of trailer-on-flatcar (TOFC) and container-on-flatcar (COFC) traffic.

More important than fuel efficiency and environmental problems to the rail industry is that, in the continuing analysis of the industry by the Federal Railroad Administration (FRA), a conclusion was reached that improvement of intermodal services by the railroad industry may be able to recapture a substantial portion of the profitable market that has been diverted to competing modes.

The U.S. Department of Transportation (DOT) position on this issue is illustrated by Secretary Coleman's landmark statement of national transportation policy on September 17, 1975 (1): "The strength of our transportation system lies in its diversity, with each mode contributing its unique and inherent advantages.... A priority for reform is to encourage intermodal joint use of facilities [but] the potential of intermodal services remains for the most part unrealized." A transportation system based on policy outlined in the statement would provide "new, more cost-effective, energy-efficient and intermodal technology." These ideas were basically repeated in

Secretary Adams' 1977 policy statement on national transportation trends and choices (2).

Thus, DOT developed FRA's Intermodal Freight Program. The objectives are to develop the best marketing techniques, management and operating control systems, operating practices, and equipment concepts that can accelerate the growth of coordinated rail-highway merchandise service. Various alternatives are being tested and refined in actual service under a representative variety of operating conditions and market situations. Each demonstration project will address a distinct problem or combination of problems that defy simple solutions even on a long-term basis. DOT approval of a demonstration project specified that an important criterion of any demonstration is whether it has the potential for profitability, defined as 10 percent return on investment. How this is to be measured is the subject of this paper.

FRA INTERMODAL MANAGEMENT INFORMATION SYSTEM

An integral part of the Intermodal Freight Program is the development of a specialized Intermodal Management Information System (IMIS). Although the IMIS was introduced by FRA in order to improve the competitive situation of the TOFC mode (and consequently the railroad industry), there were other indications that such a system was needed. One was the National Intermodal Network Feasibility Study, which emphasized an IMIS as an essential feature of a successful TOFC system. Another study that reinforced FRA's belief that little attention had been given to the development of systems for intermodal use was an informal survey conducted in 1975, which concluded that the development of an IMIS would not result in a duplication of any existing, developing, or proposed system.

With the obvious industry need for an IMIS, the beginning of the FRA Intermodal Freight Program, and departmental approval of the program, a contract was awarded to Planning Research Corporation (PRC) in September 1977 to develop an intermodal information system with the following objectives:

1. To improve quality of service in (a) trailer handling in terminals and on trains and (b) loss and damage claims;
2. To improve productivity of labor (salesmen and personnel in terminals);
3. To increase revenue by (a) entering new markets through additional train, terminal, or equipment capacity and (b) assuring collection of all revenues due; and
4. To reduce expenses through improvement in use of certain kinds of labor and capital, which includes (a) tractor drivers and the labor and capital on ramps, (b) equipment such as trailers, cars, and other supplies, (c) terminals, and (d) trains.

STATE-OF-THE-ART SURVEY

The first task was a state-of-the-art survey to determine the extent to which systems that directly support intermodal service have been developed. The survey was designed to obtain information on a wide range of intermodal organizational, informational, and operational characteristics. It was intended to encompass not only the railroad industry, but also segments of the motor carrier and maritime industries.

The objectives of the survey were to determine the state of existing and planned systems that support any or all aspects of intermodal activity and to identify unmet needs. A sample of eight railroads was surveyed in detail. To be representative of the full range of industry practices, the sample selected included large and small carriers, differing intermodal organizations, integrated and independent motor carrier subsidiaries, and geographic balance. In addition, one common carrier, two trucking subsidiaries, and one international maritime carrier were included to further diversify the investigation of intermodal activities. Findings of the survey were verified by a search of pertinent literature and systems-related research.

The survey questionnaire was designed to capture characteristics of the intermodal operations, sales, marketing, pricing, costing, and data-processing environment with emphasis on the degree to which each functional area is capable of being automated. To solicit maximum cooperation, each rail carrier selected was initially contacted through the chairman of the Association of American Railroads (AAR) Intermodal Ad Hoc Steering Committee. The rail carriers were requested to complete the questionnaire and subsequently to review their responses with an on-site survey team. To coordinate the information collected, the carriers were asked to describe existing and planned systems for each intermodal function. In addition to responding to the survey, many carriers supplied reports now in use that support intermodal services.

Since the state-of-the-art survey deliberately limited the number of carriers, it was both appropriate and necessary to conduct a literature search to ensure that the study adequately reflected the current level of intermodal systems development, both in rail and in other transportation modes. In this way, information systems excluded from detailed examination by time and budget constraints could be documented if they were available through the literature review. Recent literature about management information systems in the intermodal area is sparse; it consists mainly of articles in trade publications and papers presented at conferences. The search concentrated on trade publications after 1970. As would be expected in publications intended for general readership, the articles described systems only in the most general terms, and the search revealed little that was not already included in the survey.

It was found that all railroads (except the smallest) now have some type of automated system in support of intermodal management and control. These vary widely in sophistication, in the degree to which mechanized processing is employed, and in the extent to which intermodal processing is involved within existing rail systems.

In the railroads surveyed, there were many consistent factors that related to intermodal data processing. At first glance, this consistency supports the premise that development of an intermodal system compatible to many would be a relatively simple task. Other factors, however, tend to make the task more complex. Key findings are discussed below.

Development Status

The intermodal component of the railroad industry is currently experiencing a surge of system design, development, and implementation activity unmatched in its history. This trend to enhance or develop systems in support of intermodal processing should be strongly encouraged, given the limited resources of most railroads and the relatively low priority attached to intermodal operations in general. Should the degree of system development for intermodal operations continue and actually increase, it is felt that future intermodal profitability would be significantly enhanced through improved management control and resource allocation.

Distinctive Intermodal Requirements

An independent IMIS that encompasses all aspects of intermodal activities does not exist. Several systems applicable to intermodal service were developed by converting or modifying (or both) conventional car systems. Intermodal requirements are met by these systems only to a limited extent, since they do not recognize certain distinctively intermodal needs. The need for certain approaches tailored to intermodal system design is beginning to be recognized, and some railroads are cautiously taking that approach.

Intermodal service has two characteristics that differentiate it from conventional carload traffic and result in unique information requirements. With intermodal service, the trailer is the revenue-earning unit comparable to the car. However, the trailer requires a car for movement on rail; the result is that two pieces of equipment are needed, whereas carload traffic requires only one. In addition, although cars are "married" to the rails, trailers frequently move out of railroad control, which requires that adequate records of street activity be maintained.

In general, a dichotomy in intermodal design activity was observed: Some railroads very successfully and easily converted or modified (or both) car systems to intermodal systems, whereas others found it more difficult to add intermodal capabilities to their existing systems.

Certain intermodal processing activities such as trailer control would be enhanced by independent development of intermodal systems applications in lieu of adapting conventional carload systems to meet the divergent intermodal requirements.

Trailer Control Systems

Most railroads surveyed consider an automated Intermodal Management Equipment Control System (IMECS) essential to future growth. An intermodal equipment control system, as defined here, primarily provides a real-time inventory of trailers and containers at the intermodal terminal that gives information such as the number out to a customer and the number of loads or empties in the yard. This type of intermodal processing was identified differently by the various railroads surveyed, which used terms such as Terminal Control System (TCS), Trailer Inventory Control (TIC), Van Inventory System Implementation Operating Network (VISION), and Intermodal Facility Inventory Control. Only one major railroad surveyed has implemented an intermodal equipment control system. This system is tightly interwoven with their car control system and their hardware and software configuration. This precludes it from being transferable. For most railroads, the automated status of the trailer is not carried any further than its arrival at the TOFC terminal on the rail car and is not recaptured until it is again loaded on a flatcar for movement. Several railroads are in the process of developing this capability, with implementation scheduled for the near future. In general, the intermodal organizations surveyed indicated that this application has a high priority and that other intermodal subsystems could be readily added subsequent to its implementation.

Repetitive Waybilling

The development of repetitive waybilling systems was considered essential by many intermodal departments. Most railroads surveyed had not yet implemented repetitive waybilling for intermodal traffic. Repetitive waybilling may be more suited to intermodal than to carload traffic, since a higher percentage of this traffic follows a repetitive pattern. The ancillary uses of an implemented repetitive waybilling system are numerous and perhaps represent the greatest long-term benefits.

Profitability Analysis

A common need throughout the industry is the automatic provision of more-specific performance measures in addition to the generation of dollars of costs and dollars of revenue on a more timely and accurate basis.

The only universal aspect of costing found in the survey was that all railroads perform cost studies. Each has designed its own costing methodology, which depends on its unique competitive, operational, or traffic pattern characteristics. Only one major railroad was found to have developed a regularly computer-produced profit-and-loss statement of intermodal movements by terminal, by city pairs, or by equipment type. Several of the carriers produced such a report manually by using settled revenues and average costs. Although many of them saw enormous benefit in such a report on a regular basis, differing management styles and lack of data base precluded any immediate plans to implement one. Most automated cost reports are generated from responsibility accounting systems and contain some average (allocated) costs. The accuracy of allocation methods used for general overhead, loss, damage, and several other costs is often a source of contention between intermodal and other functional areas of the organization.

Automated Detention Billing

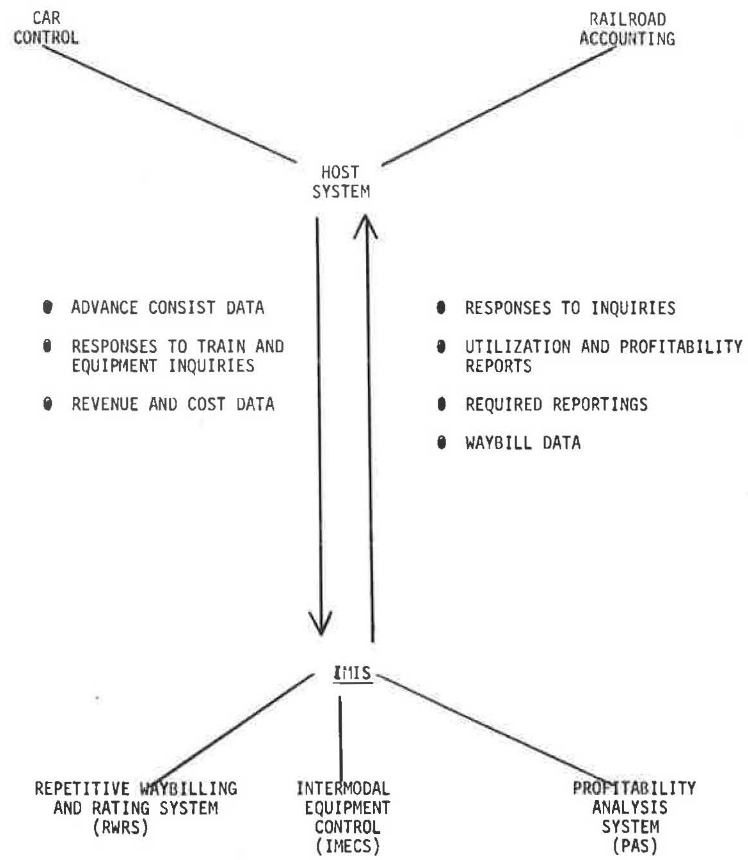
None of the railroads surveyed has totally automated detention billing. It was described as a very difficult procedure to automate, since it is dependent on numerous variables not readily obtained. The current clerical effort to rate and produce bills varies widely from railroad to railroad. With the advent of on-line intermodal equipment control systems, the automation of detention should logically follow, since the necessary data will be captured.

DEVELOPMENT OF THE BASELINE SYSTEM

With the survey findings outlined above, FRA decided to enter into phase 3 of the IMIS project and contracted with PRC to develop the system. The baseline system consists of intermodal equipment control, repetitive waybilling and rating (which is a reflection of revenue), and associated responsibility cost data. When combined with equipment data, the revenue and cost information is a profitability-analysis tool. Together these items form the IMIS, but (more importantly) they provide the foundation and data base for expansion into many other areas; hence, they form a baseline system. The IMIS will support equipment distribution and inventory, budget control, management by objective, and, in short, increased profitability.

By the previous designation of the components of the baseline system, it may seem that the marketing and pricing and the sales functions have been

Figure 1. Relationship of Intermodal Management Information System (IMIS) to existing railroad systems.



overlooked. To the contrary, many of the organizations surveyed that were concerned with these functions considered intermodal operations as a major informational source. Reports of cars loaded or empty and of the balance between the two direct the attention of sales and marketing departments to areas of imbalanced traffic, and comparative reports of customer activity can be drawn from historical data of trailer movement. Specific information on the intermodal operations functions is of more-immediate importance than that for use solely by marketing, pricing, or sales. For this reason, the marketing, pricing, and sales functions have received a lower priority for specific development than the baseline system components. By providing the baseline data base, these other functions can also be served, and there is the added advantage of laying a foundation for their future expansion within the IMIS.

It is important to realize that the baseline system is essential; it provides a broad, substantial foundation that immediately addresses critical intermodal information requirements. It is simpler and less costly to develop and implement a variety of reports without a baseline system and corresponding data base, but such an approach does not provide the railroads with the means to add and expand for long-term capabilities. The primary criteria for developing the baseline system are modularity and transferability--modularity to accommodate current needs as well as future expansion and transferability to allow maximum use by the intermodal organizations of the railroad industry.

Approaching the design from the top and working down enforces modularity. Transferability is fostered by developing an IMIS that is largely independent of existing railroad systems but still linked to those systems to avoid redundant efforts. The baseline system begins where those systems cease their control of intermodal activities and in turn terminates its scope where existing rail systems again take over. This relationship of the IMIS to existing railroad systems is shown in Figure 1.

The initial task was to specify the development of a baseline system. Each of the major components (intermodal equipment control, repetitive waybilling and rating, and profitability analysis) will be further refined into its component parts and supported definitions of functions, inputs, outputs, and transformations. The baseline system specification includes (a) purpose and scope; (b) design concepts and assumptions; (c) functional system description overview; (d) detailed specifications, i.e., IMECS, Repetitive Waybilling and Rating System (RWRS), and Profitability-Analysis System (PAS); (e) computer resource requirements; (f) software interfaces; (g) user input parameters; (h) output report layouts; and (i) data base definition.

Intermodal Equipment Control System

The foundation of the baseline system is IMECS. Not only does it provide data for profitability and performance analyses but, by its provision of real-time inventories of trailer location and status, it supports greater control of terminals and improved use of intermodal equipment. Possible equipment status is shown in Table 1.

On-line inquiries provide a good basis for terminal management personnel to make necessary adjustments to their daily operations. However, control of terminals includes not only tracking the trailer within the intermodal terminal, but also monitoring trailer detention by the customer and

Table 1. Possible equipment status as shown by IMECS.

Status	Flatcar	Van or Container
Ramp placement	X	X
Ramp departure	X	X
Bad order	X	X
En route	X	X
Available empty	X	X
Assigned empty	X	X
Gate arrival		X
Gate departure		X
Interchange delivered		X
Interchange received		X
Grounded		X
Notified		X
Picked up		X
Returned		X
Delivered to customer		X
Released by customer		X
Loaded on flatcar		X
Manifested		X
Stored on per diem relief		X
Released from per diem relief		X
Stored	X	X
Disposed of old equipment	X	X
Receipt of new equipment	X	X
Tendered	X	X

recording interchange by truck with other carriers. Reports on equipment overdue from maintenance shops and patrons, or idle for extended periods of time without being stored, identify areas for improving turnaround times. Due to the recording of status and location changes, detention times are available. From the state-of-the-art survey, it is known that detention rating systems vary from railroad to railroad. However, with the implementation of an externally supplied rate table, detention billing becomes feasible.

At the system level, current situation reports should provide for more-efficient distribution of empty equipment; this makes it possible to achieve an important reduction in empty trailer miles. In addition to real-time inventory conditions, the intermodal-management and home-office personnel would have access to historical data compiled by IMECS. All the data to produce an analysis of the facility's cycle of activities are available, and it is possible to automate a morning report that gives a synopsis of yesterday's activities for each intermodal terminal and hence for the system.

A detailed list of inquiries and reports should be produced by the general design specification; however, the following should be included: (a) inquiries about trailers by means of equipment identification; (b) summaries of trailers by a subset of available data elements, especially loaded versus empty, plan number, equipment type, and status (this provides the on-line situation report); (c) inquiries about outstanding customer notifications; (d) daily situation report at system level (i.e., aggregation of individual reports); (e) morning report; (f) report of overdue or idle equipment; (g) per-diem relief summaries; (h) analysis of facility's cycle of activities; and (i) detention summaries and bills.

This is not meant to be a definitive list of all the reports because it is important to remember that the baseline IMECS provides a comprehensive data base capable of producing a variety of reports. It is intended that the baseline system produce a few reports considered basic to any intermodal operation. In addition, each railroad can use the data base to yield reports that reflect its own operating emphasis and particular interest.

The host computer system (the railroad's on-line operations control system) will provide advance consist data, which include estimated time of arrival and waybill information for the conveying flatcar and for all the vans or containers it carries. These data will allow IMECS to automatically create inventory records of that equipment whose current status is "en route." If data on a given railroad's consist are not sufficient for our purposes, advance consist data can be entered manually. The host system also provides responses to inquiries about the various trains and equipment that it is currently supporting. The intent is to maximize the use of existing systems. IMECS will not capture these types of data for its files but will switch the host responses to a cathode-ray tube or printer for use in the advanced-planning process at the intermodal terminal.

Since each railroad's requirements for data will vary, so will the amount of data that flows from IMECS to the host system. This is why the modular approach is so important to the design. Inquiries on IMECS files should be allowed from the host and from any other user. Additional reports that may be required will have to be developed separately for each railroad.

Given the integrated data base provided by IMECS, other functions can be provided in succeeding phases of implementation, such as customer orders, blocking of trailers and cars, flatcar matching, and crew work assignments.

Repetitive Waybilling and Rating

The RWRS greatly simplifies the billing process and provides a timely and accurate revenue data base. The system complies with standards currently in existence for repetitive waybilling and rating yet provides for distinctively intermodal requirements in the revenue-capturing process. The general approach was to capitalize on prior development characteristics of similar systems for carload and intermodal traffic and to tailor existing design criteria for the baseline IMIS. Waybill preparation for the intermodal traffic that the railroad originates or controls (i.e., local traffic, interline forwarded traffic, and miscellaneous charges) is approached in a fashion typical within the industry. The source data-entry system uses proven concepts in which, in a typical case, the billing clerk calls out a pattern (the waybill profile) and then fills in any blanks. The hard-copy bill will be produced when requested, the billing data (extract information) are forwarded to other functional areas that require such data (central accounting and movement systems, for example), and these data are retained on the local system for subsequent recall, correction, embellishment, or other use. The process by which the waybill information is retained is especially critical to intermodal traffic. Time-saving automated techniques are built into the RWRS to aid the movement of either paired or unpaired trailers. The variable input data will be edited by interactive graphics to verify format and consistency with trailer inventory.

Within the RWRS component of the baseline system, the following four subfunctions have been developed:

1. Interactive capture and printing of the waybill,
2. Real-time rating of waybills through application of repetitive rate structures,
3. Generation of freight bill information when appropriate, and
4. Provision for a revenue data base that will include all repetitive shipments.

The system has been developed in a modular fashion to permit both those railroads that have already implemented a repetitive-based system and those railroads that can provide revenue via another method to tie in with other components of the IMIS. In addition, the system operates in conjunction with existing railroad accounting procedures and car movement systems. Transportation Data Coordinating Committee specifications have been adhered to so that the system can provide for the electronic interchange of waybilling information.

Baseline system development for profitability analysis has focused on providing a data base of information that concerns the profitability of intermodal services performed by the railroad. Two aspects of data definition are critical to the development of profitability analysis as a tool for many users. First, data elements must be identified that are conducive to effective profit measurement and performance evaluation. Second, a data base must be defined to maintain these elements at a level of detail compatible with extraction and aggregation of the information for differing levels of management organization. Three general categories of data elements are essential: movement, revenue, and costs.

Movement

Data for monitoring van or container movement and equipment use are furnished for profitability analysis by the IMECS of the recommended baseline system. IMECS will supply the key elements of time and movement of individual trailers or containers. Several identifying characteristics associated with the movement of intermodal equipment are included in the profitability-analysis data base so that the movement information can be extracted and summarized in various ways. For example, all records that contain the same customer identity could be selected and aggregated to provide information by customer. The most common displays of information noted during the state-of-the-art survey visits were by terminal, origin or destination, customer, commodity, plan, and equipment type.

Revenue

The state-of-the-art survey also noted that a high percentage of intermodal traffic (as much as 95 percent) follows a repetitive pattern. A substantial portion of the revenue for intermodal movement can then be captured from rated waybills provided by the RWRS of the baseline system. The revenue thus obtained reflects amounts very close to the actual settled revenue.

To determine revenue not included in repetitive, rated waybills, two methods are used: (a) estimation of the revenue based on historical performance and (b) provision for manual or automated entry of settled revenue--essentially, the revenue in the data base created from repetitive shipments would be updated as settled revenue is reported; thus 100 percent of revenue is provided on a historical basis.

In any case, it is expected that revenue at the level of an individual trailer or container supplied from RWRS will be the primary source of revenue input for profitability analysis.

Costs

The third data category--cost input--is not so easily derived as movement and revenue inputs. The proposed baseline system does not directly provide for the capture of all intermodal costs at the level of an individual trailer or container, since it is especially in the area of accounting for costs that divergent management practices prevail. It is here that profitability analysis must relate to existing railroad accounting procedures and be able to accept input at the level of accounting desired by each railroad.

To accomplish this task, a high-level structure that divides costs into commonly acceptable categories (e.g., line-haul versus facility costs, variable operating expense versus fixed operating expense) has been established as a framework for a chart of cost accounts. The identification of detailed components making up each category and the level of accounting at which the cost element is established are left to the discretion of the user. The method of determining the per-unit cost for appropriate costs must also be defined by the user, e.g., system average, manually calculated input, percentage allocations, standards. The intent is to measure cost in terms of individual van or container movement or at some level at which individual movements can be aggregated, so that a common base can be established for relating the movement and revenue data to costs incurred.

The data thus collected provide a pool of information variables that may be selected and related to each other in many ways. When dollars of revenue and costs are desired for a given terminal, the van or container movement records into and out of that terminal provide the key for pulling together and aggregating revenue and cost data associated with the terminal's traffic. Other variable and fixed expenses of the terminal's operation that are not directly associated with trailer or container movement are then determined based on the parameters defined by the railroad, e.g., some percentage of total agency overhead supplied by a responsibility accounting source. It can be seen that once the important profitability data elements are made available to levels that permit meaningful relationships to occur, any number of relationships (such as operating ratios or load factor) can be formed. The continuous maintenance of these data elements then forms the historical data base, which can be used in subsequent comparisons of current and previous activity. If the data are available, a railroad could establish its historical data base at one time. The historical data base could serve other uses, at the discretion of the railroad, e.g., modeling and forecasting.

For the proposed baseline system, forecasts and budgets are areas of optional input to be identified at the discretion of the user. Definition of any element as input does not preclude its automated generation from some railroad's existing system; the only limitation to such an automated input is the formatting of the value from the existing system so that it can be recognized as profitability-analysis input.

The Norfolk and Western Railway Company (N&W) (a subcontractor) recognizes profit and loss as important criteria for evaluating performance. To demonstrate the baseline system's capability for profitability analysis, a terminal profit-and-loss statement similar to the one in use at N&W has been generated for pilot demonstration testing.

The N&W shows revenue broken down into categories of inbound, outbound, other, and detention; segregation by still other categories (such as plan number) could be easily accomplished provided the revenue input data included the necessary identification of such controlling items.

The N&W expenses are identified by their responsibility accounting reports. Their pyramid of expense breakdown starts with the entire system's profit-and-loss report and breaks down to those of individual ramps. The baseline-system approach to capturing these cost elements is to allow the railroad to identify the cost accounts to be used and to input these cost items to the profitability-analysis system. In the case of N&W, an interface between the responsibility accounting system and some of each month's total cost elements is required. The profit/loss and revenue/cost ratios are then calculated.

The historical elements of revenue and cost (i.e., data from the same month last year, from the year to date, and from last year to date) are retrieved from the profitability-analysis data base. Accordingly, those elements entered into the system for each month become part of the historical data base, in which they can be modified and updated (if necessary) to provide subsequent historical comparative values. Forecasts or budgets could be entered and shown for the comparisons if the railroad so desired.

To calculate the revenue or cost per unit and per load, movement data for traffic volume and loaded or empty status (provided by IMECS) are used. The movement data also provide the basis for the operating characteristics that management wants reported.

Reports to indicate load balances, to compare patron activity, and to portray empty line-haul costs compared with those for loaded mileage are other examples of operating statistics that could be derived from the profitability-analysis data base.

Profitability-Analysis System

In summary, the goals of the profitability-analysis component of the baseline system are to establish a data base of intermodal activity, revenue, and costs and to provide flexible, comparative reporting of the data at both detailed and summary levels. Movement data are supplied by the IMECS, revenue data are provided primarily from the RWRS, and most data will be obtained by interfacing with railroad financial and management systems to include intermodal service costs, directly related expenses (responsibility accounting), and transportation costs. The modular design will permit movement and revenue data either to be omitted or to be also input from sources external to the baseline IMIS should a railroad choose not to implement either or both of these baseline systems. Historical data will evolve from the collection of these inputs over time; forecasts and budgets will need to be entered from external sources if desired.

The design of the profitability-analysis component is of a generalized nature, so that the level of detail and control can be substantially determined by each railroad. Easy manipulation and retrieval of the data allow profitability reports to be formed to serve the varied needs of the management components within a railroad, and the concept can be adapted to suit the purpose of each railroad. A profit-and-loss statement for a terminal is one way in which profitability information may be portrayed. Traffic and operating statistics are still other ways.

The profitability-analysis concept allows for any number of future additions and enhancements, particularly data on those functions now designated as obtainable by interfacing with individual railroads. The importance of the baseline system is the establishment of a means for collecting intermodal profitability and performance information.

A major IMIS objective is to design and program the system to minimize dependence on one type of computer and to enhance the potential for widespread railroad industry adoption of the system. Therefore, the IMIS software is distinct from that of existing rail systems yet is able to interface with existing railroad central computer systems.

To avoid dependence on one computer, protocols have been developed to define standard transaction and data-element formats. IMIS has been written to communicate with existing central systems in terms of these established protocols. In addition, IMIS programming uses a widely available, high-level language to maximize its transferability.

Hardware Alternatives

There are two basic hardware alternatives for installing the IMIS: the same computer as the railroad's on-line operations control system or a separate computer.

There are several significant drawbacks to sharing the same computer as the on-line operations system:

1. From the state-of-the-art survey, it was learned that many of the railroads' computers are close to the saturation point. The addition of the IMIS, especially if written in a high-level language, may exceed the core-storage or disk-storage limitations of the host computer system. Hardware costs for computer sharing appear to be less than the second option because existing equipment is used. However, if additional core, disk or tape drives, communications lines, etc., must be purchased to include the IMIS, hardware costs may meet or even exceed those of the second alternative. This is true whether the computer saturation occurs as soon as IMIS is added or later. Accordingly, the hardware expense is dependent on the railroad's computer capacity.
2. Most on-line systems possess idiosyncrasies (such as specialized multithreading techniques, input-output overlap techniques, partition requirements, and other core-mapping techniques) that make independence of the installation, even with our interface modules, very difficult and costly in terms of software. This alternative is also the least transferable. Moreover, there is a possibility of greater impact on the host computer because some elements of the host system, such as the teleprocessing programs, may have to be modified to include the IMIS. Such modifications also increase the software cost.
3. Sharing the host computer is less acceptable to the industry than the other alternative because of potential compromise to the integrity of the host computer's on-line system. Those in charge of existing railroad computer systems will be extremely reluctant to allow direct access to their data bases and teleprocessing programs by new software because the process of error resolution (already difficult in an on-line system) is compounded by the presence of such software.

The alternative that has been recommended to handle intermodal operations is a dedicated computer. The most appropriate type would be a minicomputer. This option has the following advantages:

1. This alternative offers a well-defined interface with the host computer via a communication link, which virtually eliminates all need for the IMIS to accommodate and compensate for installation-dependent idiosyncrasies. Only that logic directly involved in simulating the host computer's terminals and transactions needs to be

isolated in an interface module, and thus this option provides greater transferability.

2. The initial hardware cost is a variable that depends on the size of the individual railroad's intermodal operations. There will be a higher initial hardware cost if an additional computer is used; however, if the IMIS causes the host computer to become saturated, later hardware costs could exceed the cost of a dedicated minicomputer. Also, development of the IMIS on a minicomputer that is upwardly compatible allows the system to operate on more than one size of computer. This enables railroads with a small volume of intermodal data to use a small, less-expensive minicomputer and provides a system that railroads with large intermodal operations can implement on a larger machine.

3. By providing an independent IMIS, the potential compromise of the host system's integrity is eliminated. This makes it more acceptable to the industry and lessens the software costs. At the same time, the computer used for intermodal data does not perform most of its processing synchronously with the host computer, which causes little adverse impact on host-computer performance standards and core- and disk-storage requirements.

TERMINAL COMMUNICATIONS DEVICES

Devices that communicate with the IMIS system also require discussion. There are three basic types: a cathode-ray tube (CRT), an intelligent terminal, and a minicomputer.

A CRT, often called a dumb terminal, is a simple mechanical device for transmitting and receiving data images. It provides no processing of data at the local level. Of the three types, it is the least expensive. It can be used best at locations in which the volume of intermodal data is low.

An intelligent terminal is a more-sophisticated device. Typically, it consists of a CRT with a small amount of core, auxiliary storage, and a printer. It can provide processing of the input data prior to its transmission to the IMIS system. This processing can take the form of preliminary or low-level editing of the input data, which would reduce the load on the communication line and the central minicomputer by eliminating unproductive transmissions. Input or output images can be retained for subsequent communication or printing. Additional functions for use only at the local level can be programmed for the local terminal. Such functions can be run in an off-line mode to fit the needs of the individual location. Simple functions that require little storage are the most feasible for the intelligent terminals. Because intelligent terminals provide more capabilities, they cost more. They would best be employed at facilities with substantial volumes of intermodal input data.

A minicomputer provides the maximum capability for local processing. Greater amounts of core and auxiliary storage allow availability of numerous, more-complex functions. Any of the functions listed for consideration in future phases of IMECS could be implemented as a part of the central IMIS. However, since these are essentially local functions, they could be distributed to the local minicomputer; this would decrease communications costs and provide greater capabilities. In addition, one minicomputer could be used to support the needs of both its resident location and those locations in the same geographic area too small to justify having their own computer. Minicomputers have the greatest potential for future development; they also represent the greatest hardware costs. Thus, they are best suited for facilities with the largest intermodal operations or for support of several operations from one point.

These three types of devices provide great flexibility in the implementation of the IMIS. Any one can be selected, or all three can be used simultaneously. Each railroad can tailor the configuration of its terminal communications devices to fit its resources and information requirements. This flexibility also allows for future upgrading of a railroad's hardware capabilities to reflect the changing conditions of the intermodal services provided by the railroad.

As mentioned earlier, the FRA-developed system has undergone a pilot demonstration on the Norfolk and Western railroad. The demonstration traffic lane was between Detroit and St. Louis with communications links to the railroad headquarters in Roanoke, Virginia, and to the contractor's computer in McLean, Virginia. All three modules were in operation and profitability reports were prepared by traffic lane for the two terminals involved and system intermodal profitability.

On completion of the pilot program, a review was concluded, and corrections were made to the baseline specifications and detailed specifications. These were delivered to FRA along with training manuals and programming instructions. This material is available to any railroad from the Federal Railroad Administration in Washington, D.C.

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