A topology of financial versus manufacturing management information systems

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Manufacturing management information systems (MIS) are in a relatively less mature state than financial information systems. This difference in maturity is due, in part, to historical reasons, and to the complex and dynamic nature of manufacturing system attributes. This paper compares the various system attributes belonging to manufacturing and financial information systems. Application of inappropriate system design techniques (based on these system attribute differences) has contributed to the relatively high failure rate of manufacturing MIS. The paper analyzes the need for the development of design tools geared specifically toward manufacturing MIS.

Keywords: Management information systems, financial information systems, manufacturing information systems, systems analysis and design.

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1. Introduction

Historically, much of our systems resources have been devoted to the development and implementation of financial MIS. These information systems have progressed from highly structured transactions processing systems (TPS) to less structured decision support systems. Kaplan [14] explains that accounting and control systems 'do not produce the key non-financial data required for effective and efficient operations' in a production environment. Manufacturing MIS are currently at a less mature state than the financial systems [24]. In general, there are far fewer types of systems than is available in the financial environment. Manufacturing MIS differ from financial information systems as displayed in table 1.

- Manufacturing MIS experience a relatively high failure rate, compared to financial information systems.

Computer Integrated Manufacturing systems' (CIM) breakdown and disruption has been noted in the industrial engineering literature. Breakdowns are attributed, in part, to the size and complexity of manufacturing systems [21]. High failure rates of Flexible Manufacturing Systems (FMS) have been attributed to a tendency to develop applications for non-bottleneck resources

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Table 1
Comparison of financial versus manufacturing management information systems (adapted from Copeland and Globerson [7]).

Attribute	Financial MIS	Manufacturing MIS
Objective	Provide information about assets, liabilities income, cash flows	Provide management with information regarding productivity, quality and human performance
Major users	External parties, chief executives, financial managers	Internal parties, operations managers, supervisors
Frequency of reporting	Monthly, quarterly yearly	Continuously, up to a few weeks
Setting policy	Accounting policy	Multiple techniques depending on circumstances

[10]. This results, at least in part, from system development by designers who are not acquainted with manufacturing needs [10].

- Historically, there has been an uneven allocation of systems development resources towards financial information system development, to the detriment of manufacturing systems.

The uneven allocation of systems development resources has been noted by Wight [24], one of the originators of MRP (material requirements planning) concepts. MRP (now MRP-II) is one of the fundamental existing manufacturing management systems.

- As a result of the less mature state of manufacturing management systems, the marginal benefit of developing new successful manufacturing management systems should exceed that of new financial systems.

Research in manufacturing systems has called for the integration of managerial and technological classes of manufacturing systems (to be described below) into broad based CIMs. Expectations are that CIM has strong profit potential [9]. These expectations are based, in part, on the phenomenon of manufacturing management systems being in a relatively immature state. Other existing manufacturing management systems e.g., OPT (Optimized Production Technology) have been shown to be very beneficial as have the successful parts of MRP-II installations [11]. These examples indicate that opportunity exists for the implementation of quality manufacturing information systems.

Management information systems are typically divided into major functional subsystems (marketing, manufacturing, personnel, finance and accounting, etc.). Each subsystem is unique in its procedures, programs, models, etc.

Manufacturing information systems are divided into two categories: technology oriented, and management oriented (fig. 1). A fairly high degree of attention has been paid to the technology side (e.g., CAD/CAM, robotics, etc.). However, as stated before, the management side of manufacturing systems remains much less mature, relative to financial management systems.

As shown in fig. 1, there exist several types of manufacturing management systems. We will divide manufacturing systems into two main categories: project management systems (i.e., CPM, PERT), and resource management systems (MRP-II for resource management, scheduling, capacity planning, etc.). Lately, the OPT (Optimized Production Technology) system by Creative Output, Inc. has become widely recognized both as a managerial concept and a production software package. OPT defines different measures of performance for operations management, and uses some rules, techniques, and heuristics to identify bottlenecks in the process. The Japanese experience with JIT (Just in Time) philosophy and using Kanban methods for scheduling has spread lately to the United States. For further information on PERT, CPM, MRP-II, and OPT, the reader is referred to Chase and Aquilano [5].

This paper observes the phenomenon of uneven allocation of systems development resources. We propose certain factors that have impeded the development of manufacturing management systems, leading to this uneven allocation of resources.

(1) Manufacturing management systems differ in their nature and behavior from financial systems.

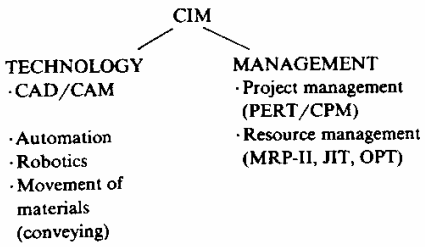

Fig. 1. Classes of manufacturing systems.

(2) The manufacturing systems environment is objectively different from the usual financial environment.
(3) A contributor to the dismal manufacturing MIS performance is the use of design tools developed in the financial world, for the creation of manufacturing systems. Whereas design tools in the financial environment are suited to relatively static and structured systems, manufacturing systems often lack structure and are quite dynamic.

Section 2 presents a general model for the comparison of different types of information systems. Section 3 examines the various differences between financial and manufacturing systems, in terms of the nature and behavior of their components. Section 4 discusses the implications of these differences on the traditional allocation of systems development resources, and its impact on manufacturing MIS.

2. A general model for the comparison of information systems

Churchman [6] defines the following five major elements (among others) that comprise a system: environment, role, components, arrangement of components, and resources required to support the system. Our comparison of system types deals with the differences between components of financial and manufacturing management systems. Information systems can be broken down into five distinct components: hardware, software, data, people and procedures [15]. Data runs through a system, and is transformed into useful output information (fig. 2).

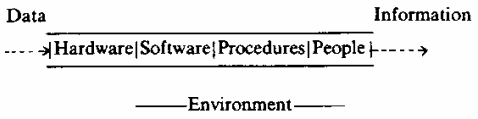

Fig. 2. Components of an information system.

Each of these components of an information system has various attributes, whose nature and behavior may vary according to system type. A summary of some of these component attributes follows in table 2.

3. Financial versus manufacturing information systems

This section follows the framework described in table 2. Financial and manufacturing MIS are compared along these various parameters. Some financial systems fall into the category of decision support systems (DSS). These DSS differ from our perception of transactions processing and MIS systems in terms of degree of structure, cost, longetivity, etc. [23]. For that reason, our discussion begins with the comparison of manufacturing management to financial management transactions processing and MIS systems. Later, we note similarities between manufacturing systems and financial decision support systems in terms of system dynamics and structure. Little research has

Table 2
Components and attributes of an information system.

Data	– types – volume – lifespan – dynamic/static nature – origin – timeliness – criticality – cost
Hardware	– Input/output media and communication
Software	– Static/dynamic nature – Degree of process structure – Existence of standards
Procedures	– Formal/informal – number – complexity
People	– Number of distinct user levels – Degree of user heterogeneity
Information	– Format – contents – timeliness – cost [1] – Tangibleness of benefits
Environment	– Adaptive/organic vs. mechanistic – Degree of uncertainty

been done regarding decision support systems as they relate to manufacturing management themselves [18].

3.1. System data

Table 3 describes those data attributes that differ between manufacturing and financial systems. Note that for financial systems, we describe data characteristics that hold true for transactions processing and MIS type systems. We will note that the least complex manufacturing systems have many characteristics similar to the more complex financial systems (decision support). This is true of amount of data types, flexibility of system, volume of data, ill-defined process structure [23].

Fig. 3 illustrates the difference between the main attributes of manufacturing and financial data. Data dynamics (changeability and timeliness of data) in manufacturing management systems is relatively higher than that of financial systems. The data changeability of a TPS manufacturing system is as high as more complex financial systems (DSS etc.). However, the volume of data in each type of information system is higher in all types of financial systems.

A financial firm that adds a new product (e.g., a 'new' IRA fund), generally follows a similar framework for the processing of information, management and clients reports, etc., relative to its existing product line. However, when a manufacturing firm adds new products (or even produces an existing product for a new client), it is typical to encounter a new framework for processing of information, management and client reports, etc. This framework may not resemble that of any previous situation.

High technology industries require many levels of assembly. These manufacturing systems utilize many processes. As such, a manufacturing management system will require a broad milieu of data. Manufacturing systems require many types of data, each type generally in low volume. It has also been noted [20] that the detailed informational requirements of a manufacturing management system are not well defined. McLean et al. [17], speaking about the 'factory of the future', Flexible Manufacturing Systems (FMS), and robotics, indicate that in the future, manufacturing processes will be more complex. To accommodate this, manufacturing systems will need more types of data. Simple financial information systems (transactions processing) typically process limited types of data, each of which may have large volume. More complex financial systems (i.e., DSS) may have somewhat more types of data, with lesser volume.

Table 3
Comparison of data attributes.

Attributes	Financial systems	Manufacturing systems
Types of data	Relatively few	Relatively many
Volume per type of data	Large	Small
Lifespan of data	Long	Short
Nature of data	Relatively static	Relatively dynamic

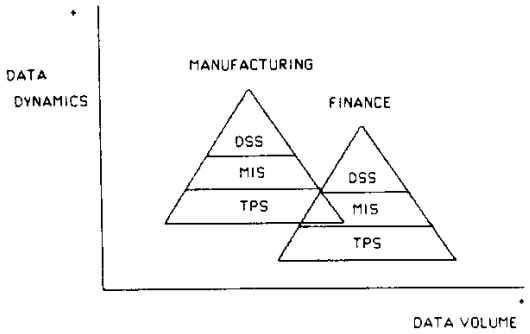

Fig. 3. Financial data versus manufacturing data.

As discussed, manufacturing data is considered highly dynamic. This is influenced by the constant change in production requirements. According to Wight [24], the only constant for manufacturing data is change. Thus, the least complex manufacturing systems (transactions processing) resemble the most complex financial systems (decision support) in regard to data types, volumes, and system flexibility.

Short time to market is critical in the manufacturing environment [10]. In order to accomplish this, data has to be generated speedily. Manufacturing often encounters changes to products, implying that data has a relatively short time to obsolescence. Financial data has a relatively long lifespan, out of necessity for conservativism imposed by audit requirements. This is further discussed by Kaplan [12,13,14].

3.2. System hardware

Financial and manufacturing information systems hardware differ primarily in terms of the variety of input/output devices that are needed. Manufacturing systems have special communication problems that are derived from the use of many input/output devices. Manufacturing systems receive data directly from other machinery (e.g., CAD/CAM) through optical readers, bar code readers, etc.. Machinery are often nominally incompatible, resulting in the need for complex interfaces. Though financial information can be transmitted through automatic teller machines (ATM), point of sale terminals, etc., the variety of industrial hardware is much greater.

3.3. Applications software

Manufacturing applications are highly fluid. As has been discussed, a manufacturing system is subject to constant change. Modifications may be necessary with the introduction of new customers and new products. Financial applications are much more static [13] than manufacturing applications. Once again we note resemblance between manufacturing systems and financial decision support systems.

It is commonplace for manufacturing software to maintain two distinct databases. One database services technological (engineering) data, the other services management data. The complexity of manufacturing systems has made the integration of these two genders of databases difficult. See Beely [3] and Kutchner and Gorin [16] for more details.

Few standards exist for manufacturing management software. Even standards for MRP [19] are far away from the well established standards for general ledger or financial reporting applications. A documented problem with MRP-II development has been the inability of data processing staff to deliver software before changes in business conditions made the specifications obsolete [11]. The existence of relatively few standards makes reliance on unaltered off-the-shelf software for manufacturing virtually impossible. Sepehri [22] notes that there exists little or no manufacturing software packages for process, repetitive, or batch types of manufacturing. Manufacturing applications must be developed for ill-structured problems, adding to the complexity of manufacturing software development. Unlike financial decision support system development, manufacturing systems are not perceived as inexpensive, or 'quick hit' systems. Hence, the creation of ill-structrured manufacturing applications is time-consuming, difficult, and financially risky.

3.4. System procedures

Manual procedures relating to financial systems tend to be highly formalized [13]. Standard reasons include conservatism, need for auditability, dealing with highly liquid assets, etc. Manufacturing systems may lack formal procedures for many processes. As a result, there tends to be more reliance on informal procedures.

Number and complexity of procedures will be a consequence of software complexity, data nature, and degree of procedure formality. Therefore, we would expect manufacturing management procedures to be relatively more numerous and complex than the financial system counterparts.

3.5. People

Manufacturing personnel exhibit informal behavior. The manufacturing manager is considerably less disciplined than his financial counterpart. The manufacturing manager's basic responsibility is the production of quality merchandise in a timely, cost efficient manner. Reporting that is associated with the production task is of secondary priority to the manager.

The major responsibility of a financial system is the generation of quality *information* in a timely, cost effective manner. Financial personnel, therefore, behave more formally than the manufacturing counterpart.

Manufacturing systems have more heterogeneous users than financial systems. A production process requires the interface of managers and engineers. These different user types may use 'different languages', yet they must communicate information to each other. Financial systems relate to a more homogeneous pool of system users.

3.6. Information

Table 4 compares the attributes of information between manufacturing and financial systems.

Table 4
Comparison of financial versus manufacturing information.

	Financial systems	Manufacturing systems
Format	Relatively rigid	Relatively flexible
Contents	Need for accuracy	More flexible accuracy requirements
Information benefits	Tangible	Less tangible

Manufacturing information is more complex than financial information. Manufacturing information will deal with many products. The systems' informational requirements may change rapidly. Financial systems have need for precision. These systems deal with the representation of highly liquid assets. Errors may have a material effect on the income statement. Manufacturing systems require accuracy. However, there is some slack for less than precise information.

Automation of financial systems may have fairly tangible expected systems benefits. For example, an automated financial system may reduce clerical staffing requirements. More timely information regarding cash position will result in more efficient investment of idle cash balances. Automation of manufacturing systems will have some tangible benefits, e.g., better inventory handling, however, these benefits are difficult to predict at the onset of system development.

3.7. System evironment

Manufacturing systems deal in a rapidly changing environment. Manufacturing systems tend to be of the adaptive/organic nature. The system itself is very much influenced by the outside environment. Changes to the marketplace will result in quick production changes. Any production change will manifest itself on a manufacturing information system. Changes to the marketplace will occur in a fairly unpredictable nature. Financial systems tend to be more mechanistic. These systems are somewhat less influenced by the outside environment, and operate in a more stable, predictable system state.

4. Implications of system differences on systems development

At this point, we will assess the various reasons that there has been an allocation of system development resources in favor of financial MIS. One reason for this phenomenon is historical in nature. After discussion of these historical factors, the discussion will shift to the implications of financial versus manufacturing systems differences on systems development.

4.1. Historical underpinnings

One reason for the emphasis on the development of financial systems to the detriment of manufacturing systems is historical in nature. The corporate controller, or accounting department historically controlled the information systems resource. Therefore, it is natural to understand that accounting applications received priority. Manufacturing systems were perceived as a 'necessary but separate part of the organization' [9]. Legislation requires timely reporting of financial information (employee withholding, SEC and IRS reports, etc.). Financial systems receive priority in development and maintenance since they require precise outputs (due to the clearcut impact of errors on financial information).

There is no doubt that historical issues have played into this emphasis on financial systems. However, these historical reasons do not account for the continued tilted allocation of resources. Recent trends find that managers regard management of the manufacturing area an integral part of the overall strategy for a successful organization [9]. The continued allocation of resources tilt may then, in part, be due to differences in the nature and behavior of financial versus manufacturing MIS.

4.2. The impact of differing system characteristics

As we have seen in the previous section, manufacturing management systems generally have more dynamic input data, complex hardware, lack of problem structure or defined standards, informal procedures, user heterogeneity, and deal in a highly dynamic environment.

We observe at the onset, that development of manufacturing information systems is a risky venture. Since there is little standardization of production information requirements, software vendors are dissuaded from producing packaged manufacturing management software [22].

Since manufacturing management systems are

large and expensive, conventional wisdom would employ structured design techniques for the creation of manufacturing systems. We have already observed the resemblance between the most complex, ill-structured financial systems (DSS) with manufacturing MIS. Structured design techniques, while useful for well-structured financial systems, are considered inappropriate for the development of the more complex financial decision support systems [23]. This is due to the DSS traits of dynamic nature of data, ill-structured problems, informal procedures, dynamic system state, etc. It appears that manufacturing management systems have many of the same characteristics that make structured design inappropriate for financial decision support systems.

The adoption of decision support system development methodologies would also be inappropriate for manufacturing system design, even for manufacturing transactions processing systems. Manufacturing systems are large and expensive. Decision support systems development methodologies adopt an iterative approach, not very useful for manufacturing management situations. Iterative design [23] is not highly regarded for large system development, since it adopts a 'bottom-up' approach. It appears that a distinct approach to system design is necessary to accommodate these distinct manufacturing systems. The approach will need to be a hybrid of the two development paradigms (structured versus iterative design).

5. Conclusions

Manufacturing MIS differ from financial MIS in regard to system and environmental attributes. These attributes have dissuaded the development of manufacturing management systems in favor of the more structured, more stable financial information systems. This uneven allocation of system development resources has left manufacturing management systems in a less mature state of development than the financial systems. This gives an excellent opportunity from the cost/benefit point of view [8] to produce profitable manufacturing information systems. According to Copeland and Globerson [7], the total organization would benefit if the financial consequences of operational actions were measured better. This is further evidenced by performance of successful MRP-II and OPT systems, and by the CIM literature. This research recognizes distinct differences between manufacturing and financial systems. It further recognizes that there lacks adequate system design tools for manufacturing management system development. This is a first step in the pursuit of a new, more even allocation of systems development resources to tap the potential of manufacturing management systems development.

References

[1] Ahituv, N., A systematic approach toward assessing the value of an information system, MIS Quarterly (December 1980) 61–75.
[2] Ahituv, N., M.C. Murno and Y. Wand, The value of information in information analysis, Information and Management 4 (1981) 143–149.
[3] Beely, W.D., The heart of integration: a sound data base, IEEE Spectrum 20(5) (1983) 44–48.
[4] Buffa, E.S., Modern production/operations management, 7th ed. (John Wiley & Sons, New York, 1983).
[5] Chase, R.B. and N.J. Aquilano, Production and operations management, 4th ed. (Richard D. Irwin, Inc., Homewood, IL, 1985).
[6] Churchman, C.W., The system approach (Dell Publishing Co., New York, 1968).
[7] Copeland, R. and S. Globerson, Improving operational performance in service industries, Industrial Management (July/August 1986) 23–28.
[8] Emery, J.C., Cost/benefit analysis of information systems, in: J.D. Cougar and K.W. Knapp, Eds., Systems analysis techniques (Wiley, New York, 1974).
[9] Ford, F.N., W.N. Ledbetter and B.S. Gaber, The evolving factory of the future: integrating manufacturing and information systems, Information and Managemgnt 8 (1985) 75–80.
[10] Goldratt, E.M. and R.E. Fox, The race for a competitive edge (Creative Output Inc., Milford, CT, 1986).
[11] Kamenetzky, R.D., Successful MRP II implementation can be complemented by smart scheduling, sequencing systems, Industrial Engineering (October 1985) 44–52.
[12] Kaplan, R.S., Measuring manufacturing performance: a new challenge for managerial accounting research, Accounting Review 58 (1983) 686–704.
[13] Kaplan, R.S., The evolution of management accounting, Accounting Review 59 (1984) 390–418.
[14] Kaplan, R.S., Yesterday's accounting undermines production, Harvard Business Review (July-August 1984) 95–101.
[15] Kroenke, D.M., Business computer systems, 2nd ed. (Mitchel Publishing, Inc., Santa Cruz, CA, 1984).
[16] Kutchner, M. and E. Gorin, Moving data, not paper, enhances productivity, IEEE Spectrum 20(5) (1983) 84–88.
[17] McLean, C., M. Mitchell and E. Barkmeyer, A computer architecture for small batch manufacturing, IEEE Spectrum 20(5) (1983) 59–64.

[18] Nof, S.Y. and R. Gwrecki, MDSS: manufacturing decision support system, Proceedings of the AIIE Spring Conference, Atlanta, GA (May 1980).
[19] Orlicky, J.A., Materials requirement planning (McGraw-Hill, New York, 1975).
[20] Polus, G.B.C. and P.D. Weill, A new classification system for production control, Proceedings of the Conference on Engineering Management (1985).
[21] Scalpone, R.W., Eductional process is vital to realization of CIM benefits and handling of pitfalls, Industrial Engineering (October 1984) 110–116.
[22] Sepehri, M., Newest manufacturing software packages offer modules which meet specialized needs, Industrial Engineering (October 1985) 28–43.
[23] Sprague, R.H. and E.D. Carlson, Building effective decision support systems (Prentice Hall, Englewood Cliffs, NJ, 1982).
[24] Wight, O.W., Tools for profit, Datamation 26(10) (1980) 93–96.