A VIABLE SYSTEMS MODEL APPROACH TO ENTERPRISE RESOURCES PLANNING SYSTEMS

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ABSTRACT

The Viable System Model (VSM) is recursive and helps explaining the general production management model of the ERP system. The recursion level explains the development starting from warehouse management to Material Requirement Planning (MRP), to Manufactory Requirement Planning (MRPII), to Enterprise Resources Planning (ERP), and to Supply Chain Management (SCM).

In each recursion level, the emergent concepts helps explaining the discovery of the two categories of demand: independent demand and dependent demand, the feedback concept helps explaining the closed cycles in ERP, the local, future and total environment concept helps explaining the interactions between the market and the Production System and the Law of requisite variety helps to manage complexity.

Keywords: Viable Systems Model (VSM), Enterprise Resources Planning (ERP), Recursion Level.

INTRODUCTION

Management of manufacturing systems is the science, art and profession to lead such systems from a state of development to a different and better state of development. The processes of improving manufacturing systems are well known. One of these fundamental processes is the planning and control of Materials, Energy and Information (MEI) flow.

Research, planning and control of the MEI flux is taught since the early days of Taylor's industrial management, but it was until 1975, when Joseph Orlicky published his seminal book "Materials Requirements Planning", when learning on this new techniques began.

For any enterprise, the focus of financial management is the capital flow. In ERP systems, production and financial management are the core function, while other modules, either offer services or provide them, Financial management reflects an enterprise's business performance and managerial efficiency (Zhuqiang Zhu, 2006).

According to the cybernetic model of any Viable System Model, there are five systems interactively involved in any organization that is capable of maintaining its identity and transcend independently of other organizations within a shared environment (Beer,1989). If an organization survives in a particular sort of environment, it is viable.

All manufacturing systems are embedded in a continuously changing world economy system and environment. Success in global and local markets with social satisfaction requires constant unrelenting efforts to develop more viable manufacturing systems, aware of quality and sustainability.

SYSTEMS CONCEPTS

The following brief systems concepts descriptions, help understand the development of enterprise resources planning (ERP) systems (Laszlo, 2003, Crete Glossary. Communication for the *ISSS 47th Annual Conference*):

General System Theory. The concepts, principles and models that are common to all kinds of systems and isomorphism among various types of systems.

System. A group of interacting components that keep some identifiable set of relationships with the sum of their components in addition to relationships (i.e. the systems themselves) to other entities.

Subsystem. A greater system's component, is made up of two or more interacting and interdependent components. The subsystems of a system interact in order to attain their own purpose(s) and the purpose(s) of the systems in which they are embedded.

Model building. A disciplined inquiry by means of which a conceptual (abstract) system's representation is constructed or an expected outcome/output representation is portrayed. There are models of function structure (like a still picture) and models of processes (like a motion picture).

Function. Denotes actions that have to be carried out in order to meet system's requirement and attain the purposes of the system.

Human activity system. A system with purpose, that expresses some human activities of definite purpose; the activities belong to the real world.

Viable system model. It is a system able to maintain a separate existence, capable of maintaining its identity and transcend independently.

Environment. The context within which a system exists, includes everything that may affect the system and may be affected by it at any given time.

Variety. Number of possible states that a system is capable of exhibiting (Beer, 1979).

1. General conceptual model of a production system.

The old philosophic Aristotle 's model of the four causes helps to begin the construction of a model of production system as follows:

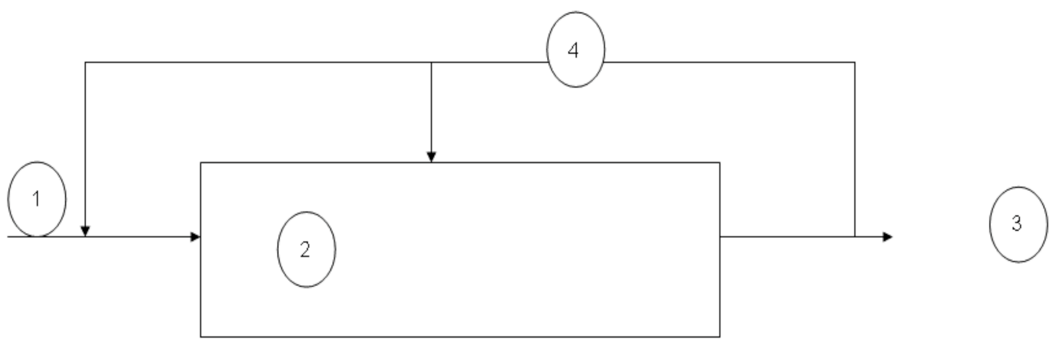


Fig.1 Four Causes Model

Table 1. Aristotle's four causes model

Aristotle cause number and name	Production System equivalent
1.- Original	Matter, Energy and Information (MEI) input
2.- Formal	Transformation of MEI
3.- Final	output approximating to the real third cause
4.- Efficient	Management of causes one, two and three.

The above initial model can be improved up to become the Beer's Viable System Model (VSM) (1979, 1985, 1994, Espejo & Harnden,1989) to produce a better representation of an actual Production System including fundamental functions which are also ERP functions.

VSM approach to ERP systems

The VSM presents a new way of looking at an organizational structure. It is a recursive model in which each successive unit is nested within the next larger one. It is a pre-eminent way to manage variety. It is a logical structure which differs from a classical hierarchical organizational chart but helps management to organize effectively the Production System.

According to Guo & Yolles , (2006:15) “organizational theory and managerial wisdom suggest that, in order to survive and flourish, organizations must be compatible with their environments, which include all external social , economic and political conditions that influence their operations”

To be compatible with its environment means that a production system needs to process the variety of its environment to be equal to the variety of the system itself and the variety of the system to be equal to the variety of its management. This process is represented in the theory of viable systems in which the ability of the system to survive depends on its ability to create requisite variety (Ashby,1956; Ashby, 1964 in Yolles, 2007).

The Viable System Model sets out the necessary functions of operation/ implementation, coordination, auditing/ control, intelligence and policy that must be present in any viable enterprise and suggests what information systems have to be in place to support viability (Greogory, 2007).

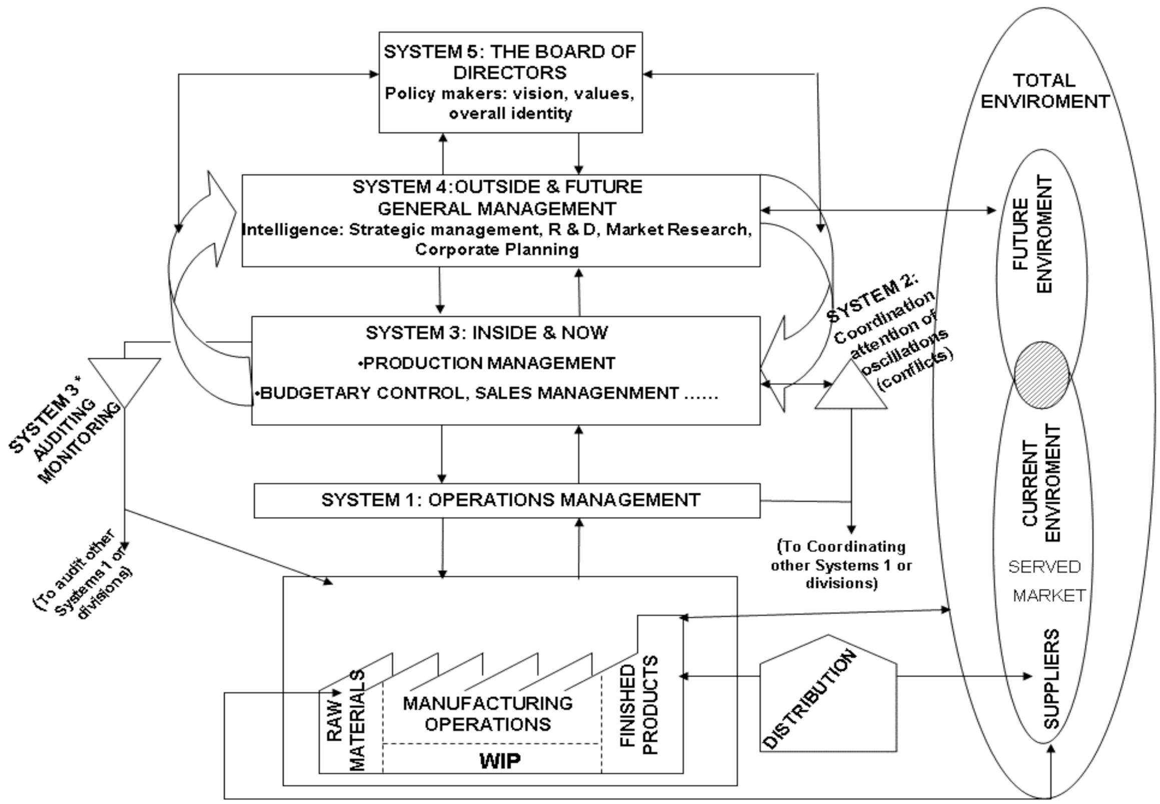
Enterprise Resources Planning (ERP) is an information system that helps production systems to reach viability through several modules that process data and information as close to real time as possible and directs the information that flows around the various communication linkages shown in Fig. 2 and 3.

A viable system “is a system with an identity and purpose which is, in principle, capable of surviving its appointed time, whether definite or indefinite” (Leonard in Beer, 1994:347). The VSM is made of five subsystems/elements that in this paper are designed as 1)operations management, 2)coordination, 3)auditing/monitoring, 3)production management, 4)general management and 5)board of directors.

In a Viable System Model, System Four is concerned with the future (the outside and then: Budget of long range forecast and marketing) as apposed to system three‘s concern with the present (inside and now: the best integration and coordination of existing resources. production logistic such as master production schedule, resources requirement planning, materials & capacity).

Sales and operation management is a typical system one function managed by system three, monitored by system 3* and coordinated (avoiding conflicts) by system 2.

Following Jackson (2000: 158-162) and Leonard (2006, 2007) let see how the modules of ERP help to perform the functions of the VSM’s five systems.



WIP= Work in process

Fig. 2. General Production System Model based on VSM

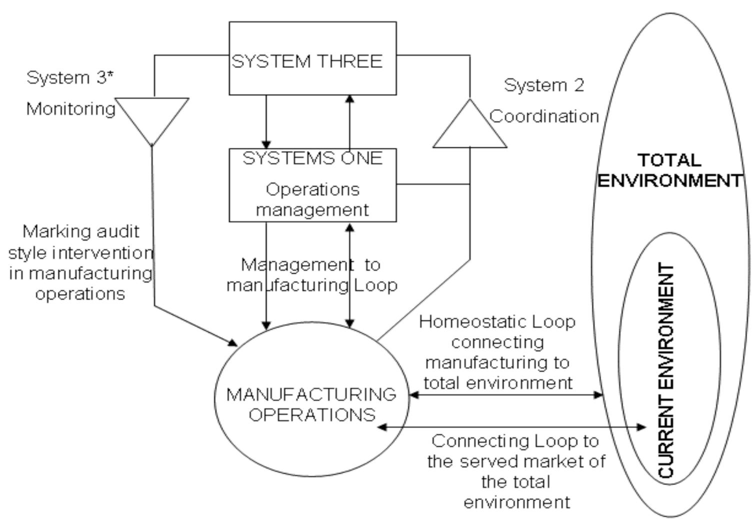


Fig. 3. Details of interactions between System One and its environment (customers suppliers and shareholders, communities)

VSM approach to ERP systems

System 1

The system one of a production system produces the system and consist of the various components directly concerned with carrying out the tasks that the production in a system is supposed to be doing, such as the tasks performed by some of the following ERP modules, shown on Table 2:

Table 2. ERP's Modules for System 1 of VSM.

1. Sales and operation management (SOP)	2. Customer Relationship Management (CRM)
3. Quality Function Deployment (QFD)	4. Master Production Schedule (MPS)
5. Material Requirement Planning (MRP)	6. Capacity Requirement Planning (CRP)
7. Bill of Material (BOM)	8. Bill of Processes (BOP)
9. Shop floor Control (SFC)	10. Production Activity Control (PAC)
11. Suppliers Relationship Management (SRM)	12. Total Quality Control (TQM)
13. Maintenance Management (MM)	13 Distribution Requirement Planning (DRP)

Each manufacturing department is connected to the wider management system by the vertical communication channels to receive instructions and to report performance, preferable on standard forms (Landvater, 1989).

In order to be viable systems, each manufacturing department should be autonomous and be able to make its own decision.

System 2

This system has a coordination function whose main task is to assure that the various manufacturing departments of a production system act in harmony. It is the system 2's job to oversee the interaction between departments and to stabilize the situation to obtain a balance response from system 1. Normally this coordination function is located inside the Manufacturing Engineering office and uses some modules of ERP such as those shown on Table 3:

Table 3. ERP's Modules for System 2 of VSM.

- Production Scheduling (MPS)	- Quality control of major Raw Materials
- Work procedures / Bill of processes (BOP)	- Maintenance Management (MM)

*Systems 3 and 3**

System 3 is a command control function. It interprets policy in the light of internal data from system 2 and monitoring or auditing reports from system 3*. The task of the last one is to give system 3 direct access to the state of affairs in the operations of system 1. Through this channel, system 3 can get immediate information, rather than relaying on information passed to it by the localized management of production departments. For example to check directly on quality, maintenance procedures, employee morale, etc.

The ERP modules that can help system 3 to command and accomplish control functions are shown in Table 4:

Table 4. ERP' Modules for System 3 and 3* of VSM.

Shop Floor Control (SFC)	Financial Business Modules like:
Manufacturing Execution System (MES) (to control and monitoring of plant-floor machines and electromechanical systems)	Activity Based Costing (ABC) to get real cost of finished products or services
Input – Output control and Production Activity Control (PAC) (to control details of production flow)	Accounts Payable (AP),
Human Resource Management (HRM) (for payroll, time management benefits administration, etc.).	Accounts Receivable (AR),
Plant and Equipment Management (FA) (Fixed assets management)	General Ledger (GL), (for controller, accounting, auditing, internal control, taxes reports, etc.)
Shop Floor Control (SFC)	Fixed Assets (FA), (for depreciations replacements)
	Payroll (PR), for salary administration, social security,
	Profit and cost center accounting etc.

From the accountants and financial perspective, there should be one of two fundamental objectives in a production system. One is to obtain the capability to produce a product or service that can be sold at a profit represented by A/R, A/P, F/A, etc. The second, is to improve an existing product or service so as to improve performance and customer acceptance, or reduce cost (with the help of "ABC" lean practices, etc.) without sacrificing customer acceptance either of which would lead to higher profits.

From the information processing point of view, the capacity of managers in system 3, of carrying out the control function, needs to be in balance with the current information flowing through the three incoming channels: 1) Coordination from system 2) auditing/ monitoring from system 3*, and 3) command from system 1.

Systems 2 (coordination), 3* (monitoring) and 3 (production management) are highly dependent on timely and accurate reporting of what is happening in system 1 (operation management, manufacturing operations and its environment).

It makes no sense to install and expensive data collection subsystem of ERP if the data are not close to real time as possible (Turbide, 2007). The big dream of accountants is not to be faced with the "month end" syndrome and real time data approach to a solution because the ERP systems are updated all the time (Currant & Keller, 1998). ERP changes the accountants´ role in system 3 because they have more time to assist management in system

3 as general advisors who can use the numbers to reduce variety and improve management of system 1. Real time data are subject to statistical filters of variety and processes to help achieving a better management of the system 1's variety.

Real time data contribute to auditing/monitoring coordination and control of system 1 through some additional ERP´s modules and functions such as:

- Advanced Planning System (APS)
- Available to promise & capable to promise functions
- Production Activity Control (PAC)
- Inventory Management (IM)

System 4

System 4 is the research and development function of a production system, it has two main tasks:

1) Translate Instructions and reports between system 5 Board of Directors and the lower – level systems.
2) To capture all relevant information for the production system, about its total environment.

If the production system is to be viable and effective it has to, somehow, match the variety of the environment in which it finds itself. To do this it must have a model of the environment that enables predictions to be made about the likely future state of the environment and allow the production system to respond in time to threats and opportunities.

System four is the point where internal and external information can be brought together. Activities such as Strategic Planning, Market research, research and development and public relations should be located there.

The ERP modules that can help perform the tasks of system 4 are shown on Table 5:

The data base of the Human Resources module (HR) helps to build a portfolio of human resources, evaluated with high potential, for HR Requirements planning in order to have the right managers in the right amount and in the right time.

The Advanced Planning System/Master Production Schedule (APS/MPS) are feed forward systems which processes current information of operations with future ideals and adjust the output model accordingly.

Table 5. ERP's modules for System 4 of VSM.

Human Resource HR	Advanced Planning System (APS)
Product Life Cycle (PLC)	Long Range Forecasts (LRF)
Legal and Fiscal Planning	Business Planning under various scenarios
Union and Community Relationship	Legal Issues

One of the most important responsibilities of system 4 is to keep adaptation mechanisms of the production systems with its future environment, represented by groups of investors shareholders, governments, unions, communities, etc.

System 5
System 5 is responsible for the direction of the whole production system; it is where identity and coherence are focused by the board of directors.

System five's activities include formulating policy on the basis of all information passed to it by system 4 and communicating the policy downward to system 3 for implementation by the production departments.

System 5 must ensure that the production system adapts to the external environment while maintaining an appropriate degree of internal stability. It is the thinking part of the production system. There are no modules of ERP to help activities of system 5 it is recommended for developers of ERP systems to design modules for consensual agreements, strategies and policy based on methodologies such as Syntegrity from S. Beer, (1994) Interactive Management from J. Warfield (1994) or CogniScope from Christakis (2007) Algedonic information coming directly from system 1 to system 5 helps to manage urgent critical situations.

2. Recursion level.

Recursion level, some times also called level of organization, is a holarchical set of entities whose properties characterize the level in question. A given entity may belong to any number of levels depending on the used criteria to link different levels "nested above and below". Fig. 4 presents 3 recursion levels for a global production system.

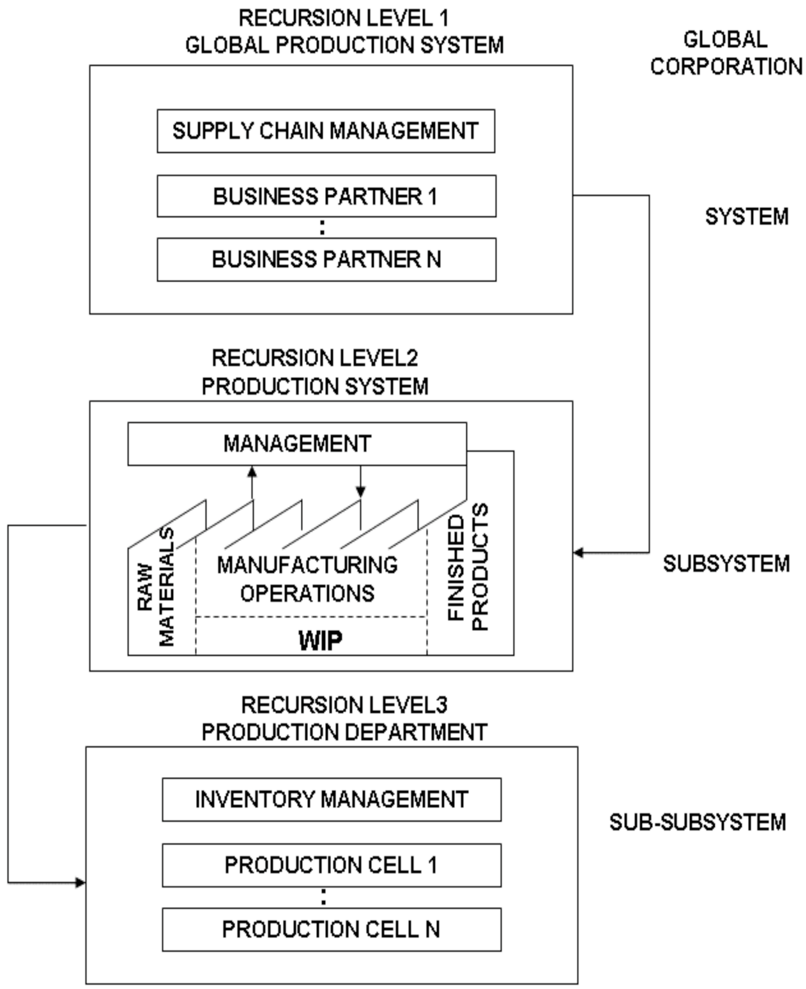


Fig. 4. A global production system with 3 recursion levels

This systemic concept helps understanding the development of ERP systems since the old inventory control systems through Materials Requirement Planning (MRP), Manufacturing Requirement Planning (MRP II), Supply Chain Management (SCM), up to Enterprise Resources Planning (ERP).

In the old times, most inventory systems of raw materials were managed by statistical techniques, because of the lack of the vision of a higher recursion level. After 1975, there were two alternatives: a) statistic inventory control (or order /quantity point technique); b) materials requirement planning (Turbide, 2004).

The theoretical work in inventory management that has been done during the past decades is generally confined to the models of Order Point and Order Quantity. Order point was a fundamental inventory management concept of raw materials when the demand was perceived as probabilistic, such was the case when the recursion level is only considered at warehouse level, but if the recursion level is raised to include the production unit and the marketing function, this technique is not valid because the demands of parts and raw materials become deterministic (Fogarty,1994; Blackstone, 2004). The previously described situation is equivalent to say that a new attribute called “dependent demand” emerged in the enlarged system.

3. Emergence

Emergence is the appearance of new characteristics exhibited on the level of recursion in question, in this case, the full production system, but not at the components such as the raw material inventory, design engineering, manufacturing engineering, sales, etc.

The new characteristics that should be considered, not only for inventory management but for management of the total MEI flow, are:

Independent demand.- This demand is unrelated to the demand for other items, particularly higher level assemblies, spare parts for finals products. Demand is defined independent when it is not a function of the demand for other inventory items. This kind of independent demand must be forecast.

Dependent demand.- This kind of demand is directly related to, or derives from, the demand for other items or final products. Such demand can, of course, be calculated. Dependent demand doesn’t need and should not be forecasted. It can be determined from the demand for those items to which it is compound (such as raw materials or purchased component parts) (Orlicky, 1970: 228-229; Plossl,1994).

The discovery of these two characteristics made by Orlicky in 1970 was expressed by him as a production management principle: “The nature of the demand is the key to inventory control technique selections and applicability”.

Since then the demand of the final products (or service parts) in a production system may have to be forecast, but none of its component’s items, (including raw materials) need to be forecasted separately, it can be calculated from the final product forecast figures or firm sales, using the several algorithms developed by marketing research profession and the software industry since then.

Another relevant emergence situation happened around the integration of data: Production Information Systems like ERP are abstract models of real human activity systems, completely integrated. Therefore it is required that all data be also very integrated across all functions and must automatically link all related records in the systems.

In order to accomplish such design requirement for an integrated database, several database management languages were proposed, for example, the Integrated Data Storage (IDS) (Veith, 1970) was a tool to describe the complex interrelationships of production systems data, as well as , a programming language to organize , manipulate and maintain these interrelationships automatically in random access environment.

When the possibilities are realized they become needs, and this was the case with IDS, since 1975 all database management systems for production systems are relational and random access.

3.1 Materials Requirements Planning (MRP)

The first MRP systems were developed and deployed by General Electric Company(G.E.) in 1965, when the memory of mainframes was measured in Kb rather than Mb. The basic idea was to calculate the quantity and timing of production and purchase orders to support the MPS, using a simple four step process: 1.- Determination of the gross requirement from the master production schedule (MPS) and bill of materials (BOM), 2.- Find expected shortages by "netting" the requirement against availability, 3.- Determination of lot sizes from order-policy rules, then 4.-Backschedulate to determine when to start the purchase or production order. The process continued level-by-level, until all requirements were satisfy.

The net calculation assumed that there was enough available capacity to complete all the activities within the specified lead times. To overcome this assumption, the capacity requirement planning (CRP) calculations were implemented and the MRP changed its name to Manufacturing Resources Planning (MRP II) (Petrof,1992; Plossl,1994).

3.2 Manufacturing Resources Planning (MRPII)

Manufacturing Resources Planning is the next step in the development of MRP, which basically consist of an additional algorithm to calculate capacity requirements of workers and machining centres, after material requirements are know. The logic of this algorithm is similar to MRP's logic.

In this case the recursion level of VSM's system one includes the production capacities of individual areas, machines and workers, which means that a bill of processes and actual database records of the available capacity will be necessary. The output reports of MRP II systems had been standardized by Landvater (1989).

3.3 Enterprise Resources Planning (ERP)

Enterprise Resource Planning is the next step in the development of MRP II which consists of the addition of several software modules to manage the main line business functions from Purchasing and Accounts Payable up to Shipping and Accounts Receivable, besides General Ledger, Payroll, Fixed Assets, etc.

3.4 Supply Chain Management (SCM)

This is the current state of ERP application which consists of a network of multiple ERP features to include the main line of suppliers, all of them working under a master production supplier- production-distribution-schedule.
In this case the recursion level includes all the suppliers, production and distribution subsystems network, which works under local ERP's systems harmonized via a communication network.

CONCLUSION

ERP systems by their own nature must be integrated. It is fruitless to attempt solving an integrated problem inside an integrated production system, with fragmented solutions.
The VSM approach to ERP has permitted an understanding and appreciation of its strengths and weaknesses .Its understanding offers a better use of the ERP's modules, its appreciation offers several opportunities to improve the designs of some modules or to create new ones. The following are some examples of improvements:

1. Maintenance of equipment will be integrated, and its scheduling will be based upon capacity requirement planning, the current used capacity and the condition of the capacity items.
2. Equipment in use will report its conduction to system 3 as well as exactly what it is doing.
3. The actual modules of MES, AP and MPS. Will develop the functionality to recommend alternate processes based upon a defined enterprise strategy.
4. Activity Based cCst (ABC). Will be codified to become a tool for evaluating business activity.
5. DRP will integrate a transportation management system.
6. The actual state of development of ERP systems produce several benefits such as:

a) Inventory reduction, b)Faster response time, c)Tight control of physical flow d)Thorough control of information and financial flow

REFERENCES

Ashby, W. 1956. *Introduction to cibernetics.* Wiley: USA.

Beer, S. 1979. *The heart of the enterprise*. Wiley: Chichester U.K.

Beer, S. 1985. *Diagnosing the system for organization.* John Wiley: New York

Beer, S. 1989. The Viable System Model: its provenance, development, methodology and pathology. In Espejo R. & Handen, R. 1989. *The Viable System Model, Interpretations and Applications of Stafford Beer 'S VSM*. Wiley: U.K.

Beer S. 1994. B*eyond Dispute: The invention of team Syntegrity. (The management cybernetics of organization).*Wiley:U.K.

Blackstone, J. et al 2005. *Apics Dictionary*. Eleventh Edition, University of Georgia: USA.

Christakis, A. 2007 CogniScope. http://www.globalagoras.org/optin.html [11 April 2007].

Currant, T. & Keller, G. 1998. *SAP R/3 Business Blueprint. Understanding the business process reference model*. Prentice Hall: USA.

Espejo R.& R S Harden R. 1989. *The Viable System Model.* Wiley: U.K.

Fogarty D. W. et al 1994. *Administración de la producción e inventários.* CECSA: México.

Gregory, A. 2007. A Systems Approach to Strategic Management. *Journals ISSS.* http://journals.isss.org/ [8 October 2007]

Guo, K. &Yolles, M. 2006. Organisational Fitness: from the Viable Systems Model to Organisational Patterning. *Journals ISSS.* http://journals.isss.org/ [13May 2007]

Jackson, M. 2000. *Systems approaches to management*. Kluver: N.Y. USA.

Landvater, V.D. 1989. *MRPII Estándar System.* Apics Press: USA.

Leonard, A. 2006. Walking the line: Making and dissolving distinctions with the Viable System Model and Team Syntegrity. *Journals ISSS*. http://journals.isss.org/ [14 June 2007]

Leonard A. 2007. Integrating Sustainability Practices Using the Viable System Model. *Journals ISSS.* http://journals.isss.org/ [10 August 2007]

Orlicky, J. 1970. *Requirement Planning Systems*. Apics Conference Proccedings 218-239. USA.

Orlicky, J 1975. *Materials Requirement Planning.* Mc. Graw Hill: New York.

Petrof, N.J. 1992. *Handbook of MRPII and JIT* . Prentice Hall: USA.

Plossl, G.W. 1994. *Orlicky's Material Requirement Planing.* 2th Ed, Mc. Graw Hill: New York.

Turbide, D. 2004. The Expanding Roots of MRP. *APICS The performance Advantage*. Vol 14 n. 10, p.35-38.

Turbide, D. 2007. Getting Real about real time. *APICS The performance Advantage*. Vol 17 n. 18, p.115.

Veith, H.F. 1970. *Production Control and Scheduling Design for the Seventies.* APICS Conference Proceeding p. 145-183.

Warfield, J. & Cardenas, R. 1994. *A Handbook of Interactive Management.* Iowa State Press: USA.

Yolles M. 2007. The sociopathology of social collectives. *Journals ISSS* http://journals.isss.org/ [10 August 2007]

Zhuqiang Zhu. 2006. A systems approach to developing and implementing an ERP financial subsystem. *Systems Research and Behavioral Science.* Volume 23, Issue 2. pp. 237-250.