Monarch Business School Switzerland
University For Graduate Studies in Management

A System Analysis Approach to Analyze and Develop ERP System Modules Based On The Principles of Lean Manufacturing

PROGRAM:	Doctor Of Professional Studies
SUBMISSION DATE:	31 August 2011
CANDIDATE:	Mr. Chalil du Plessis, B. Acc.
PROPOSAL SUPERVISOR:	Dr. Barin N. Nag, Ph.D.
THESIS SUPERVISOR:	Dr. Barin N. Nag, Ph.D.

TABLE OF CONTENTS

1.0 THESIS ABSTRACT

Lean Manufacturing Systems ("Lean"), also known as Toyota Production System (TPS), are applied in modern manufacturing to reduce waste and increase efficiency. Wherever lean manufacturing principles are applied in organizations it is often found that there are still many organizations that have two independent systems, one for manufacturing and one for the Enterprise Resource Planning (ERP). The ERP system is the one that is used for planning and integrating back-office operations.

There are currently two points of view; those who believe that the lean system must be independent of the ERP system and those who believe that an ERP system can contribute to a lean system (Bartholomew, 1999). Those who believe that the two systems should be independent argue that the lean principles promote a "pull" action through the system, constantly changing to get rid of all the waste or *muda*. Taiichi Ohno, the founder of TPS, identifies the seven types of waste in a production system as: (Ohno, 1988)

Transportation	Parts and products are moved around unnecessarily
Inventory	Accumulation of parts and products waiting to go into production
Motion	Unnecessary movement of production staff during the production process
Waiting	Waiting time spent by manufacturing staff for a previous process to complete
Over-Processing	Additional unnecessary steps are added to the production process
Over-Production	Products are produced that are not needed
Defects	Namely in a product, (Added by Womack & Jones, 2003)

The following five principles of Lean forms the antidote to waste in a lean system (Womack & Jones, 2003):

Specify Value	Only add value as needed by the customer
Identify the Value Stream	The value stream is all the steps in a production process
Flow	Make the steps in the value stream flow
Pull	Customers pull production from you. Sell one, make one
Pursue Perfection	Continuously improve by reducing time, space, cost and mistakes during the production process

On the other hand, an ERP system's main functionality is to record all historical transactions, relying on push action for production while recording transactions instead of eliminating waste (Nauhria, Wadhwa, & Pandey, 2009). The two different philosophies cause the systems to be out of sync and ERP systems are not able to contribute to lean systems (Gill, 2007).

The researcher believes that lean and ERP might not be mutually exclusive in the field of ERP systems. Vendors of ERP systems such as SAP, Oracle and Microsoft have done some work in order to facilitate lean principles by adding, modifying or enhancing their current system modules to address some of the requirements of lean systems. Most of the modules thus far concentrate on the manufacturing industry and possibly only represent lean tools or initiatives and might not necessarily apply the principles of lean philosophy and lean nature; however, there are several areas requiring study and development, such as: operations, accounting, information technology (IT), operations, and services. In 1988 the developer of the Toyota production system, Taiichi Ohno, wrote in the preface of his book *Toyota Production System: Beyond Large-Scale*

Production:

> "The Toyota production system, however, is not just a production system. I am confident it will reveal its strength as a management system adapted to today's era of global markets and high-level computerized information systems." (Ohno, 1988)

Ohno acknowledges two areas where he believes that Lean or TPS will show its strength, being: applied in the global markets and with the aid of computerized information systems. It is expected that manufacturing industries and operations will be more globally oriented in the search for higher profits. Gartner Group predicts utilization of the global supply chain as a major strategic consideration for cost reduction of companies from 2011 to 2015 (Klappich, Aimi, Taylor, & Mcneill, 2011). Economic growth until 2015 will put pressure on supply chains to be able to deliver increased consumer demand (Klappich et al., 2011). Organizations worldwide are searching for cost reduction and profit maximization methods to implement with Lean while Six Sigma gains popularity. It should be noted that Six Sigma is a quality initiative that integrates well with lean systems and TPS.

ERP systems seek to collect and record data throughout the organization. Manufacturing and other operations are regarded as part of the ERP system from an IT point of view. With Lean and Six Sigma philosophies becoming more popular in manufacturing organizations, the ERP system has to be designed to support both. Enterprise level ERP vendors such as SAP, Sage, Oracle and Microsoft have already attempted to address some of the Lean and Six Sigma concepts such as Just-in-time (JIT) and Kanban in their manufacturing and operational modules by combining functionalities such as forecasting and production planning schedules. JIT is a system referring to timing whereby items needed for the production line are delivered in the correct quantities at the correct time when and where they are needed on the production line (Hirano, 1990). Kanban is a visual system with cards attached to items containing supplier information. When more items are needed for production the card is send back to the supplier to replenish the items (J. Liker & Burr, 1999). Kanban is a tool used to achieve JIT. However, there is a lack of research and proper understanding of how ERP systems can support lean operations in the move to further globalization.

ERP systems typically focus on the organization itself and at most on inter-company functionalities but are weak in the inter-organizational functionalities required to support lean operations in the global environment. Gartner coined the phrase ERP in 1990 and in 2000 they added ERP II referring to an ERP system than will not only serve the enterprise but will be “intra-enterprise”, currently known as B2B (Business to Business) and B2C (Business to Customer). This encompasses the use of CRM (Customer Relationship Management), SCM (Supply Chain Management) and ERP (Bakht, 2003).

The test hypothesis is that ERP modules could be designed with lean principles and implemented in a global environment. In order for the hypothesis to have value, it must prove to benefit both Lean and ERP by being able to contribute to the reduction of waste as per the lean principle and to reduce costs in the traditional ERP operation. In a global environment the IT architecture and modules’ design must be of use not only for large enterprises that can afford expensive global infrastructures but must also be accessible to the small and even single entrepreneur to participate as a lean supplier in the lean supply chain.

2.0 RESEARCH QUESTION

The purpose of the research is to study ways of narrowing the gap between lean manufacturing principles and ERP applied principles. This can be achieved through analyses of already developed and implemented ERP modules that support lean principles and to develop system modules for ERP that can assist users of lean operations in a global industry that can bridge this “apparent” gap between the two systems. Thus, the thesis will attempt to answer the following specific research question:

Research Question:

> “Which are the ERP system modules that can be developed to incorporate lean principles, which will enable global lean industry users to both reduce costs in their traditional ERP system while simultaneously reducing waste?”

3.0 RESEARCH RELEVANCE

This research project will study and contribute to a relatively new and understudied area of research in ERP. The author anticipates that the study will result in the:

1. Identification of ERP system modules to support lean operations
2. Development of ERP system modules to support lean operations
3. Design of IT architecture that can support lean operations
4. Use of the developed system modules to assist users of lean operations in a global industry.

It is possible that the research could result in the result that ERP vendors may have already developed lean ERP system modules and may have already achieved the anticipated outcome of this research project. In such a case the result of the research project will contribute to the body of knowledge as valuable literature in support of the point of view that ERP systems do support the lean principles.

It is possible that the experimentation might not be able to prove the test theory that ERP modules could be designed to support lean principles. In this case, the research result will then indicate conditions under which ERP systems support Lean and conditions when ERP systems do not support Lean. It is pointed out that when there are two contrasting schools of thought, it is often the case that each school is right under certain conditions.

The study should also identify the areas most critical for further study in the near future with specific reference to lean operations in a global industry.

4.0 LITERATURE REVIEW

The thesis will be grounded in the scholarly works of influential writers in the field of Lean manufacturing and ERP (Enterprise Resource Planning). The literature review is a general overview of the literature available in the relevant field of study with respect to the research question at hand. The literature falls within the following general topics:

1. The Development of ERP Systems
2. The Development of the Lean Philosophy
3. ERP and Lean
4. Lean Operations
5. Architecture to Support Lean

Prominent authors within the field of study include such notables as: D. Bartholomew, T. Davenport, R. W. Goddard, J. P. Womack, D. Roos, D.T. Jones, J. Liker, Taiichi Ohno and B. H. Maskell.

4.1 The Development of ERP Systems

The development of ERP systems began with the development of Material Requirement Planning (MRP) in the early 1950's, which was designed to improve the calculation of material requirements in the manufacturing process to streamline the ordering process. During the 1970's MRP developed into MRPII by adding more functionality, such as: sales planning, capacity management and scheduling. Computer Integrated Manufacturing (CIM) emerged as the next step in the 1980's by embedding technical functions of product development and the production process in the MRPII system, and with the development of additional functions such as computer aided engineering and computer aided design, integrated with business administrative and technical functions (Klaus, Rosemann, & Gable, 2000). In the 1990's, ERPII expanded into a concept of a totally integrated enterprise solution into what is known today as enterprise resource planning or ERP, a term coined by the Gartner Group of Stamford, Connecticut, USA (I. Chen, 2001).

It is observed that there are differences of opinion amongst academia on the nature and definition of ERP. An analysis was done in the form of an expert opinion survey contacting twelve notable researchers in ERP, asking them to provide their own definition of the term "ERP". From the respondents, nine different points of view were received (Klaus et al., 2000). They do, however, come to the conclusion that it seems that IS adopted this name and is a commonly used term for "integrated business application packages." One definition of an ERP system is a business management system that comprises integrated sets of comprehensive software, which can be used, when successfully implemented, to manage and integrate all the business functions within an organization (Shehab, Sharp, Supramaniam, & Spedding, 2004). In this definition the emphasis is not on enterprise resource or planning but on the collaborative functionality of sets

4.2 The Development of Lean Philosophy

One of the most influential and widely cited books in operations management is *The Machine that Changed the World* by Womack and Jones (Holweg, 2007). The book was the result of five years of research at the MIT International Motor Vehicle Program (IMVP), investigating and describing the Toyota Production System, pioneered by Taiichi Ohno and Eiji Toyoda after World War II during the Japanese economic recession, comparing it with the mass production systems developed by Henry Ford and Alfred Sloan after World War I (Womack, Jones, & Roos, 1990). The research led to the inception of the phrase "lean production" that was coined by one of the IMVP researchers, John Krafcik, for this unique system designed by Ohno and Toyoda since it uses less of everything compared with a mass production system (Holweg, 2007); (Womack et al., 1990). The basic idea of the Toyota production system or lean production is “absolute elimination of waste” and that there are two pillars supporting this idea (Ohno, 1988):

1. Just-in-time (JIT)
2. Autonomation.

If Just-in-Time, (“JIT”) could be achieved the company would approach a zero level of “inventory” (Ohno, 1988). Just-in-time was one of the first concepts to be computerized as part of ERP Systems however implementing a computerized lean concept does not mean that Lean is physically implemented on the shop floor (Hirano, 1990).

Autonomation or *Jidoka* in TPS does not mean “automation” such as in a computerized system, but rather “a machine connected to an automatic stopping device” (Ohno, 1988). Such a device would stop the production immediately when a defect is detected or when there is a problem anywhere on the production line. Stopping the complete production line and correcting the problem avoids further problems and eliminates waste. Autonomation also eliminates other forms of waste such as time and cost of a person simply watching a machine when there is no problem at all. Autonomation in a computerized environment could typically be a system monitoring processes of an ERP system and could even execute corrective actions without human interaction. Such an ERP module could typically monitor for defects in database records such as missing information or inaccurate information. Defects are recognized by Lean / Six Sigma principles as a form of waste that requires re-work and does not add value to the customer (George, 2003).

Ohno (Ohno, 1988) discusses the use of computers and IS in TPS cautioning against the use of IS in the oversupply of information where it will cause confusion and disruption of the flow of the production system and therefore cause waste. He also sees the oversupply of information as a form of waste and not in line with the just-in-time principle. The cost of computers and peripherals is also a form of waste when a simple manually updated form attached to an item in production or a human action can suffice. Just-in time and autonomation will be important criteria against which to measure the successful outcome of the proposed research.

Liker (2004) expands the lean philosophy into fourteen management principles that can be applied to any kind of industry and the eighth Principle, “use only reliable, thoroughly tested technology that serves your people and processes” would be of particular interest to the research. (J. K. Liker, 2004)

4.3 ERP and Lean

ERP systems are based on concepts originating from the traditional mass production environment initiated by Henry Ford after World War I. The initial MRP systems were designed to deal with complex bill of material, insufficient workflows and unnecessary data collection (Bradford & Mayfield, 2001); (Bartholomew, 1999). Within these ERP systems MRP II is still used as the planning system with production levels based on sales forecasts. Lean production uses a “pull” system where customer demand determines the production levels (Bartholomew, 1999). Differences such as this between the two concepts have companies facing a dilemma with ERP systems wishing to implement Lean. Dixon (2004) attempts to argue a case for “other” IT applications that can support Lean but then concludes his article stating:

> "In this regard, the software industry should be challenged to get outside its tightly circumscribed world and explore the needs and opportunities outlined in this and other articles. Basic MRP software logic has not changed significantly since its invention more than 30 years ago. An ERP package completely redesigned to support the lean environment is long overdue." (Dixon, 2004)

Dixon (2004) concludes that in the future creative ways will have to be found to combine lean and ERP in order to be competitive in the market.

The dual implementation of ERP and Lean within the same organization seems to be very likely (Goddard, 2003). Corporate companies implementing Lean would have already invested in ERP systems and simply turning off the ERP system might not be feasible. In most cases the extended sub-systems of the ERP system are still needed, such as: Accounting, Human Resource Planning and Corporate Planning. (Bartholomew, 1999) Lean ERP system modules satisfying both systems can prevent companies that are implementing Lean from abandoning their ERP system for the sake of the Lean implementation.

Lean-ERP Integration Matrix
(Syspro, 2007)

Lean: ERP	FIN	HR	S & D	Mfg	MM	Logistics	Report	Bus Rules	Work Flow
Value Stream Mapping	■		■	■	■	■	■	■	■
Quality At The Source	■	■		■			■		■
Workplace Organization: 5 S	■			■	■				
TPM	■			■			■	■	■
Visual Management							■		■
Set-up Reduction	■			■	■		■	■	■
Batch Size Reduction	■			■	■		■	■	■
Cellular Manufacturing				■	■		■		■
Standardized Work								■	
Work Balancing				■				■	■
Production Leveling				■	■		■	■	■
Point-of-use Systems				■	■		■	■	■
Kaizen							■		■
Kanban					■		■	■	■

When the ERP system is seen as a value stream in the lean environment it might be possible to optimize ERP under the principles of Lean. As part of the research methodology this research will attempt to evaluate the already existing features in some of the standard commercially available ERP systems for such optimized lean features.

Syspro, a leading software development company summarized in their white paper, "*The When, Why and How of ERP support for LEAN",* the potential integration points between the nine components of ERP and fourteen lean initiatives or tools (Syspro, 2007).

In the above matrix the greyed boxes indicate the areas where ERP components and lean initiatives can potentially integrate while the blank spaces indicate where they do not.

The above matrix is an important guideline to indicate the potential areas to successfully develop Lean ERP modules. The following indicates the potential mutual exclusivity of ERP and Lean and therefore the non-integration points:

- Relevant lean tools and ERP components are not implemented for example Material Management (MM) or Inventory Control exists in the ERP but the lean Kanban tool is not implemented or not properly applied (Syspro, 2007).
- A weak implementation of an ERP module where information to be used by the lean tool does not exist or contains inaccurate information (Syspro, 2007).
- ERP systems by nature are configured once and then to repeat processes continuously whereas lean requires continuous modification in a process to move closer to the lean objectives. The inflexibility in the configuration and customization possibilities within an ERP system can force the mutual exclusivity of the two systems (Syspro, 2007).
- The implementation of an inflexible ERP system first and then lean afterwards (Lean Advisors, 2011).

However, other non-IT related factors could also cause the non-integration of the two systems, such as:

- Production orders are based on sales forecasts and not on a “pull” action from customer orders as per the lean principles (Zylstra, 1999).

- Factors such as legal and bureaucratic systems of countries can force long lead times to replenish stock forcing manufacturers to build-up stocks therefore working against the lean principle of JIT.

4.4 Lean Operations

In earlier decades, the term “operations” would primarily refer to the manufacturing operations of an enterprise but over time the term also came to include other service systems thus including all functional areas of an organization, such as: marketing, accounting, purchasing, information management, engineering and resource management (Bayraktar, Jothishankar, Tatoglu, & Wu, 2007). In the earlier sections of this proposal the discussion was primarily focused around the topic of manufacturing, however, other service systems as named above also contribute important elements to the proposed study.

These functional areas are also not without conflict when it comes to following a traditional or lean philosophy. That is to say, managers would not be able to use the traditional “manage by results” methodology in a lean environment nor judge the performance of the business correctly (Johnson, 2007). Thus, a major requirement of the study is to focus on all systems of operation to thoroughly complete the lean “thread”.

Spear and Bowen (Spear & Bowen, 1999) identified four important rules or principles for Lean operations that could be applied as metrics to measure the lean nature of the system modules. The rules are presented in the table below. Using these rules lean IT system metrics can be proposed and expanded upon below in the section “Research Methodology”.

Principles of Lean Operations (Spear & Bowen – 1999)	
Rule 1	All work must be highly specified as to content, sequence, timing and outcome.
Rule 2	Every customer-supplier connection must be direct with a yes-or-no way to send requests and receive responses.
Rule 3	The pathway for every product and service must be simple and direct.
Rule 4	Any improvement must be made in accordance with the scientific method, under guidance of a teacher, at the lowest possible level in the organization.

4.5 Architecture to Support Lean

One of the study objectives is to design or propose IT architecture to support Lean operations. Such architecture will have to adhere to the principles of Lean as mentioned earlier for the study to be successful. Today’s ERP software design developing mode might not be suitable where software reuse can only be achieved at class level. This kind of development mode results in inefficient, low quality and poor variability of the ERP system (Yue-xiao, Song, & Hui-you, 2008). A further limitation is that current ERP architecture is designed for integrating systems of a single organization and is unable to address complex and unpredictable changes in the global market (Plikynas, 2010). IT architecture designs, such as: service orientated architecture (SOA) (Mahmood, 2007) (Biennier & Legait, 2008), component based ERP with layered architecture (Yue-xiao et al., 2008) and multi-agent systems (Plikynas, 2008) have been proposed in the last few years to address software flexibility and global use of ERP systems. The research will investigate the suitability of some of these architectures through the perspective of lean global operations.

5.0 RESEARCH METHODOLOGY

The thesis research methodology will be based on systems analysis following a multi-methodological approach as proposed by Nunamaker, Chen & Purdin (1991). Their approach consists of four research strategies; theory building, experimentation, observation, and system development.

1. Theory Building:

   Grounded in the lean theory the principle hypothesis to test would be that ERP modules could be designed with lean principles and implemented in a global environment. It is expected that during the system development phase further sub-hypotheses might have to be developed for each idntified module.

2. Experimentation:

   Experimentation will be used to facilitate the observation phase as well as testing of the developed modules. The experimentation will be used to test the following metrics based on the principles of Lean operations to indicate the lean nature of the modules:

Lean Principle of Operations Metrics For a Lean Module (Spear & Bowen, 1999)	
RULE 1	**All work must be highly specified as to content, sequence, timing and outcome:** • Sequence of data entry steps are clear • Information to be entered are clear and specific • Procedures to perform a task are specified • The time to perform a task in the software can be measured and optimized
RULE 2	**Every customer-supplier connection must be direct with a yes-or-no way to send requests and receive responses:** • Information is evaluated as correct before committed to the database • Connecting processes or modules are direct and standarized • Time between each connecting process can be measured and optimized
RULE 3	**The pathway for every product and service must be simple and direct:** • Workflow through the system is simple and specific • The workflow can only change when redesigned • Workflow is specific to identify the next procedure, module and person
RULE 4	**Any improvement must be made in accordance with the scientific method, under guidance of a teacher, at the lowest possible level in the organization:** • Improvements are made scientifically and according to Rules 1- 3 for example changing the software configuration settings of the software.

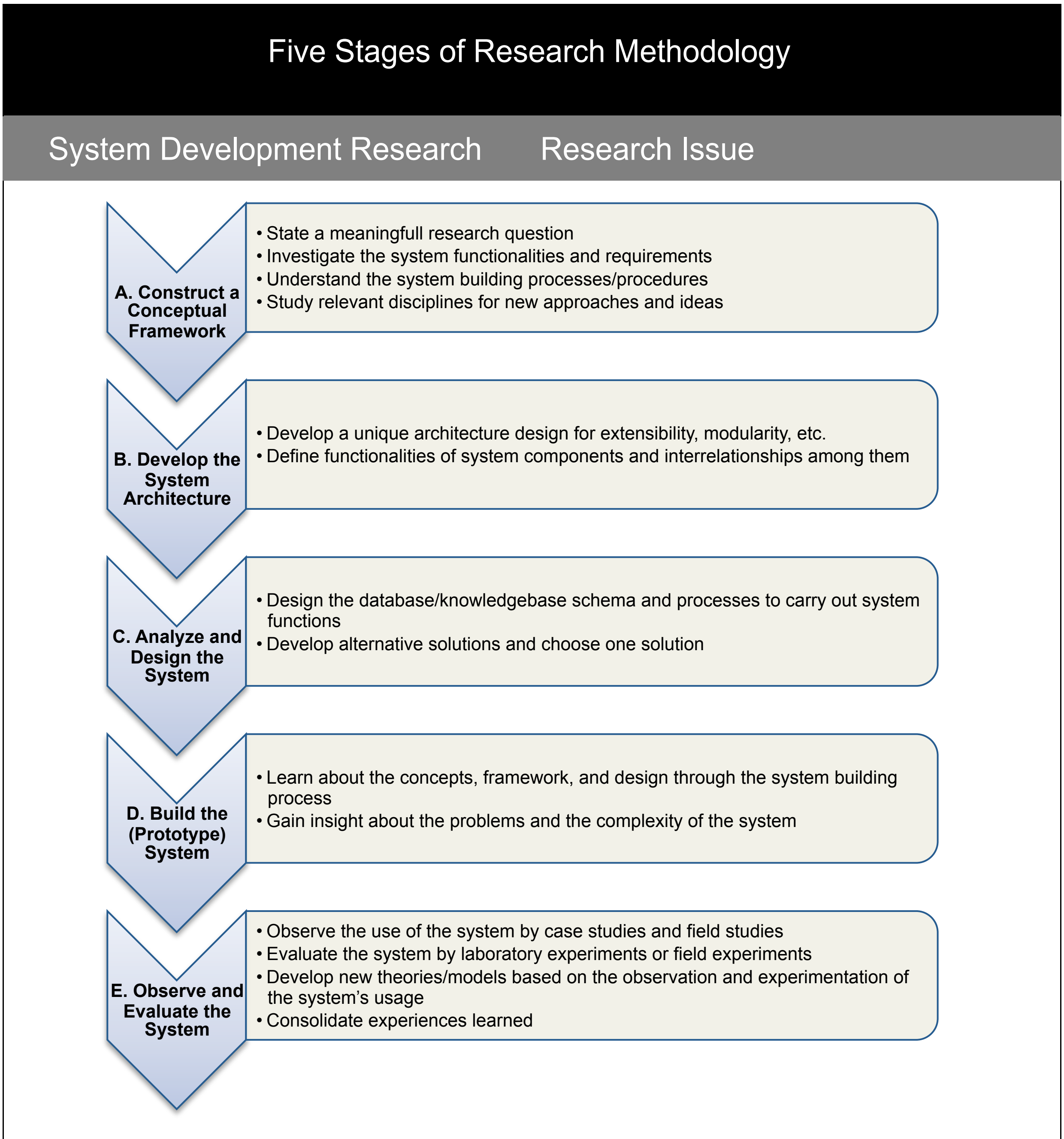
Experiments will be conducted primarily on Microsoft Dynamics AX (Microsoft White Paper, 2012) due to the authors familiarity with the software as a consultant and system analyst. Microsoft Dynamics AX demonstration software and data will be used to test results for input and output. Simulation modeling software such as Anylogics 6 will be considered for more complex experimentation required to measure time and behavior between several modules and external input for example deliveries by suppliers of inventory and customers placing orders. Integration between the simulation software, Excel models and the ERP system database can be established through ODBC connectors if required.

3. Observation:

Most of the work to collect the requirements and functionalities will be done through physical observation and analysis of existing ERP lean modules of Microsoft Dynamics AX (Microsoft White Paper, 2012). These observations can be done using demonstration packages that are available and can process data and produce results. User case data can be used to evaluate the results and behaviours to understand the “current state” of modules already developed. These user cases can also be used later in experimentation of designed modules for comparison and validation. Published case studies from vendors may also be used as a secondary source to establish requirements.

4. System Development:

System development as a research methodology consists of the following five stages and are described as a “Super-methodology” containing a hierarchy of “Sub-methodologies” as shown in the diagram on the following page:



Source: A Process for System Development Research (Nunamaker et al., 1991)

A. Construct a Conceptual Framework

This thesis proposal forms the core of the principal part of the construction of a conceptual framework for the research by stating the research question and the research relevance. In order to understand the system requirements and functionalities a GAP analysis is used. Secondary data analysis (Zikmund, 2000) of literature will be used for the requirements and functionalities of a lean system, analyzing them against the existing functionality within the existing vendor lean modules and building a GAP analysis indicating the desired requirements and functionalities for the system to be designed. The functionalities of the existing vendors modules will be analyzed by physically testing vendor demonstrations software and analysis of the vendor literature. The GAP analysis will also be the criteria against which the successful system design will be measured.

B. *Develop a System Architecture*

From the GAP analysis the architecture and modules with the functionalities will be designed. Gregor & Jones (2007) describe the architecture as the “blueprint” of an IS artifact. Words and diagrams will be used as illustrative techniques to elucidate the architectural design.

C. *Analyze and Design the System*

The required database, knowledgebase and required processes will be designed during this phase. This is a continuation of the design flow from the previous phase. Alternative solutions will also be designed during this phase while only one solution of program modules and functions will be selected for building the prototype.

D. *Build the (Prototype) System*

In order to test the original hypothesis and the underlying theories of the system it is necessary to design an artifact that can be tested based on the proposed design. During this phase the researcher will also learn if the concept, framework and design is sound and can be constructed into an artifact. For this thesis it is proposed to use Microsoft Excel to build selected algorithms that can be tested. The prototype forms also the guideline for developing the system into a product in the future by software developers.

E. *Observe and Evaluate the System*

Observation and evaluation of the prototype will form the basis of the final synthesis of the thesis. Prepared case studies will be tested using the prototype model constructed in the previous step to gather observational data that will be measured against the lean metrics as established under the experimental strategy.

6.0 RESEARCH PLAN

Research will commence immediately after the approval of the research proposal. It is estimated that the general research, literature review and construction of the framework to take approximately 14 months.

RESEARCH PLAN & SCHEDULE TIMELINE		
Doctoral Program Start	-	**February 2011**
Research Proposal Writing	6 Months	August 2011
Research Proposal Acceptance	-	September 2011
Literature Review • Development of ERP • Development of the Lean Philosophy • ERP and Lean • Lean Operations • Architecture to Support Lean	12 Months	September 2012
Framework Construction	2 Months	November 2012
Chapter 1 thru 3 Drafting	6 Months	April 2013
Phase 1 Submission	-	May 2013
Chapter 4 thru 6 Drafting	6 Months	November 2013
Final Editing	2 Months	January 2014
Submission & Defense	-	**February 2014**

Completion of the first three chapters of the manuscript for submission to the review board is expected to require another 4 to 6 months for completion. Research, data collection, writing of the final chapters, review and preparation of the final manuscript is expected to be complete after a further 12 months. The accompanying schedule represents the best estimate for the timeline and important milestones for completion of the study.

7.0 RESEARCH BUDGET

The total cost of the research is estimated to be US$ 6,000. The amount of the research is to be funded privately by the author. No scholarly grants or loans from outside agencies are required or requested. No extra supervisory cost, other costs or financial support is being requested from UGSM-Monarch Business School Switzerland. The funds are currently available as budgeted and research may commence immediately.

RESEARCH BUDGET	
Item	Cost US$
Travel and Conference Cost	$2,000
Books and Manuscripts	$1,000
Simulation Software	$1,500
Reproduction Cost – Final Manuscript Hardbound	$500
Miscellaneous Supplies	$500
Manuscript Proofreading Cost	$500
Total Cost	**$6,000**

Dissertation Approved
24-September-2011
By:

Dr. Jeffrey Henderson

8.0 BIBLIOGRAPHY

Bakht, A. (2003). Get ready for ERP, Part II. *Tribuneindia.com*. Retrieved May 18, 2011, from http://www.tribuneindia.com/2003/20031201/login/guest.htm

Bartholomew, D. (1999). Lean vs. ERP. *Industry Week*, *248*(14), 24–30. Penton Publishing.

Bayraktar, E., Jothishankar, M. C., Tatoglu, E., & Wu, T. (2007). Evolution of operations management: past, present and future. *Management Research News*, *30*(11), 843–871. Emerald Group Publishing Limited. doi:10.1108/01409170710832278

Biennier, F., & Legait, A. (2008). A Service Oriented Architecture to Support Industrial Information Systems. *Lean Business Systems and Beyond*, *257*, 93-100.

Bradford, M., & Mayfield, T. (2001). Does ERP fit in a lean world? *Strategic Finance*, *82*(11), 28-34.

Chen, I. (2001). Planning for ERP systems: analysis and future trend. *Business Process Management Journal*, *7*(5), 374–386. MCB UP Ltd.

Dixon, D. (2004). The truce between lean and IT: Technology can help enable the elimination of waste. *Industrial engineer*, *36*(6), 42–45. Institute of Industrial Engineers.

George, M. L. (2003). *Lean Six Sigma for service: how to use lean speed and Six Sigma quality to improve services and transactions* (p. 386). McGraw-Hill Professional.

Gill, R. (2007). Lean Manufacturing and ERP Systems : Different by Design. *Ceramic Industry*, *August*, 11-14.

Goddard, R. W. (2003). The role of information technology in the Lean enterprise. *IE 780S–Lean Manufacturing - Spring 2003*.

Hirano, H. (1990). *JIT Implementation Manual: The Complete Guide to Just-in-time*. *Journal of the Electrochemical Society* (Vol. 129, p. 2865). Productivity Press (Cambridge, Mass.).

Holweg, M. (2007). The genealogy of lean production. *Journal of Operations Management*, *25*(2), 420–437. Elsevier.

Johnson, H. T. (2007). Lean Dilemma: Choose System Principles or Management Accounting Controls, Not Both. *IN STENZEL, J.(Ed.) Lean Accounting: a living* *systems approach to lean management and learning. New York, John Whiley*, 3-16.

Klappich, C. D., Aimi, G., Taylor, J., & Mcneill, W. (2011). Predicts 2011 : Global Logistics Leadership a Strategic Imperative. *Leadership*, 1-10.

Klaus, H., Rosemann, M., & Gable, G. G. (2000). What is ERP? *Information Systems Frontiers*, *2*(2), 141–162. Springer.

Lean Advisors. (2011). Assessing IT's role in lean environments - Lean Case Study. Retrieved August 30, 2011, from http://www.leanadvisors.com/kila-resources/assessing_its_role_in_lean_environments/

Liker, J. K. (2004). *The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer*. *McGraw Hill, New York*. McGraw Hill, New York.

Liker, J., & Burr, K. (1999). Advanced Planning Systems as an Enabler of Lean Manufacturing. *Automotive Manufacturing & Production*, *111*(2), 29–31.

Mahmood, Z. (2007). Service oriented architecture: tools and technologies. *Benefits*, *6*, 7.

Microsoft White Paper. (2012). *Lean manufacturing : Production flows and activities*. *Production*.

Nauhria, Y., Wadhwa, S., & Pandey, S. (2009). ERP Enabled Lean Six Sigma : A Holistic Approach for Competitive Manufacturing. *Global Journal of Flexible Systems Management*. Retrieved February 12, 2011, from http://www.highbeam.com/doc/1P3-2008080711.html

Nunamaker, J. F. J., Chen, M., & Purdin, T. D. M. (1991). Systems development in information systems research. *Journal of Management Information Systems / Winter 1990-91*, *7*(3), 89-106. IEEE.

Ohno, T. (1988). *Toyota Production System: beyond large-scale production* (p. 182). Productivity Press (Cambridge, Mass.).

Plikynas, D. (2008). Extended enterprise resource planning: conceptual approach using multiagent systems. *Proceedings of the 10th WSEAS International* (pp. 380–387).

Plikynas, D. (2010). Networking Conception for E-Manufacturing Systems. *6th International Scientific Conference May 13–14, 2010, Vilnius, Lithuania*.

Shehab, E., Sharp, M., Supramaniam, L., & Spedding, T. A. (2004). Enterprise Resource Planning: An integrative review. *Business Process Management Journal*, *10*(4), 359–386. Emerald Group Publishing Limited.

Spear, S., & Bowen, H. K. (1999). Decoding the DNA of the Toyota Production System. *Harvard Business Review*, *77*, 96–108.

Syspro. (2007). The When, Why and How of ERP support for LEAN. *Syspro White Paper*.

Womack, J. P., & Jones, D. T. (2003). *Lean Thinking: Banish Waste and Create Wealth in Your Corporation*. Simon and Schuster.

Womack, J. P., Jones, D. T., & Roos, D. (1990). *The Machine that Changed the World*. *Transition*. Macmillan Publishing Company.

Yue-xiao, L., Song, H., & Hui-you, C. (2008). Research on component-based ERP system. *Journal of Communication and Computer*, *5*(10).

Zikmund, W. G. (2000). *Business Research Methods*. Thomson South -Western.

Zylstra, K. (1999). Lean Manufacturing and ERP – Conflict or Coexist ? *Deloitte and Touche*.