NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

INTEGRATED LOGISTICS: OPTIMIZING THE USMC QUADRANT MODEL USING INTELLIGENT AGENT TECHNOLOGIES

by

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March 2002

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REPORT DOCUMENTATION PAGE			*Form Approved OMB No. 0704-0188*
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington DC 20503.			
1. AGENCY USE ONLY *(Leave blank)*	**2. REPORT DATE** March 2002	**3. REPORT TYPE AND DATES COVERED** Master's Thesis	
4. TITLE AND SUBTITLE: Integrated Logistics: Innovating the USMC Quadrant Model using Intelligent Agent Technologies			**5. FUNDING NUMBERS**
6. AUTHOR Louis J. Morse			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000			**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A			**10. SPONSORING / MONITORING AGENCY REPORT NUMBER**
11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.			
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.			**12b. DISTRIBUTION CODE**
13. ABSTRACT			

In 1998, the Marine Corps initiated the Integrated Logistics Capability (ILC) to specifically address issues related to Marine Corps logistics doctrine, policy, and processes. The purposes of ILC initiatives were to define, measure, and improve core logistics capabilities to meet the challenges of the new millennium and beyond. During a four-week Best Business Practices seminar hosted by Penn State, several key concepts were analyzed that would improve cost leverage, enhance the robustness of supplier relationships, and substitute technology and information for inventory. In an effort to successfully integrate these issues, a segmentation methodology or Quadrant Model approach was introduced. The Quadrant Model is essentially a two-by-two matrix that classifies products, services, and inventory items into four major cells. Each cell is further categorized by uniqueness and value, and each cell implies different approaches to managing inventory, supply chains, and vendor relationships. The objective of this thesis is to determine how Intelligent Agent (IA) technologies may innovate the logistical processes associated the critical quadrant, which categorizes materials, products and services that are unique, high value in terms of cost, and therefore high risk. These materials may only be available from a few sources, are in limited quantities, and require extensive coordination and sharing of information between parties. The researcher applies a model derived from previous thesis work that examined the application of IA technology as a method to innovate the Standard Procurement System (SPS). Using a high-level process model of the "critical" quadrant, the researcher identifies two applications of IA technology that may support attributes within the "critical" quadrant.

14. SUBJECT TERMS Integrated Logistics Initiative, Quadrant Model, Intelligent Agent Technologies, Standard Procurement System			**15. NUMBER OF PAGES** 51
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	**18. SECURITY CLASSIFICATION OF THIS PAGE** Unclassified	**19. SECURITY CLASSIFICATION OF ABSTRACT** Unclassified	**20. LIMITATION OF ABSTRACT** UL

i

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INTEGRATED LOGISTICS: OPTIMIZING THE USMC QUADRANT MODEL USING INTELLIGENT AGENT TECHNOLOGIES

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Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
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ABSTRACT

In 1998, the Marine Corps initiated the Integrated Logistics Capability (ILC) to specifically address issues related to Marine Corps logistics doctrine, policy, and processes. The purposes of ILC initiatives were to define, measure, and improve core logistics capabilities to meet the challenges of the new millennium and beyond. During a four-week Best Business Practices seminar hosted by Penn State, several key concepts were analyzed that would improve cost leverage, enhance the robustness of supplier relationships, and substitute technology and information for inventory. In an effort to successfully integrate these issues, a segmentation methodology or Quadrant Model approach was introduced. The Quadrant Model is essentially a two-by-two matrix that classifies products, services, and inventory items into four major cells. Each cell is further categorized by uniqueness and value, and each cell implies different approaches to managing inventory, supply chains, and vendor relationships. The objective of this thesis is to determine how Intelligent Agent (IA) technologies may innovate the logistical processes associated the critical quadrant, which categorizes materials, products and services that are unique, high value in terms of cost, and therefore high risk. These materials may only be available from a few sources, are in limited quantities, and require extensive coordination and sharing of information between parties. The researcher applies a model derived from previous thesis work that examined the application of IA technology as a method to innovate the Standard Procurement System (SPS). Using a high-level process model of the "critical" quadrant, the researcher identifies two applications of IA technology that may support attributes within the "critical" quadrant.

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ACKNOWLEDGMENTS

The author would like to acknowledge the following people. To my thesis advisors, Dr. Mark E. Nissen and Dr. Kevin R. Gue, who supported this effort and offered solid advice along the way.

To my wife Kimberly, who understands my passion, my idiosyncrasies, and somehow smoothes the rough spots and wakes up with a smile. Everyday.

To Mom and Dad, who left us last summer after a long battle. Your selfless life long devotion to us has been nothing short of "above the call of duty". You're both now able to work on bigger passions as you start your second lives. We miss you always.

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I. INTRODUCTION

A. BACKGROUND

1. Integrated Logistics Initiative

This introductory chapter presents background information for the thesis, along with the objectives, research questions, scope, limitations, and assumptions associated with this research. The research methodology and expected benefits are also discussed and this chapter concludes with a section to describe the organization of the thesis. Background information includes discussions of the Integrated Logistics Initiative and its strategy and vision. The critical cell of the Quadrant Model is also outlined for understanding and to help motivate the need for enhanced decision support.

Concurrent downsizing coupled with a shrinking budget has redefined the operational environment for all the services within the Department of Defense. Mandatory reductions in force, an exodus of technical talent to the civilian workforce, and a limited resource base have forced each of the services to seek innovative means to maximize the use of constrained resources. In 1998, the Marine Corps initiated the Integrated Logistics Capability (ILC) to specifically address issues related to Marine Corps logistics doctrine, policy, and processes. The purposes of ILC initiatives were to define, measure, and improve core logistics capabilities to meet the challenges of the new millennium and beyond [Ref. 1: p. 2]. The leadership, planning, and institutionalization of ILC initiatives were assigned to the Deputy Commandant for Installations and Logistics (DC I&L), Headquarters, Marine Corps (HQMC).

In addition to improving core logistics capabilities, the ILC initiative would also analyze current supporting information technology infrastructures and explore commercial enabling technologies and solutions. The end state included the identification and implementation of commercial Best Business practices, the elimination of redundant and non-value added processes, and the integration of information technology to achieve order of magnitude improvements [Ref. 1:p. 1].

## 2.	Strategy and Vision

The ILC initiative adopted a rigorous and methodical strategy specifically aligned to the Joint Vision 2010 (JV 2010) concept of Focused Logistics, the United States Marine Corps Campaign Plan, and the Commandant's Planning Guidance [Ref. 1:p. 1]. To execute the program, a four-phase project was subsequently developed integrating the joint efforts of the USMC, Sapient Corporation, and Penn State University's Center for Logistics Research. During a four-week Best Business Practices seminar hosted by Penn State, several key concepts were analyzed that would improve cost leverage, enhance the robustness of supplier relationships, and substitute technology and information for inventory [Ref. 2:p. 11]. In an effort to successfully integrate these issues, a segmentation methodology or Quadrant Model approach was introduced.

The Quadrant Model takes advantage of innovations from commercial business practices to enhance logistics support throughout the supply chain while seeking improvements in the overall effectiveness of procurement and contracting, acquisition logistics, and material management. The Quadrant Model is essentially a two-by-two matrix that classifies products, services, and inventory items into four major cells. Each cell is further categorized by uniqueness and value, and each cell implies different approaches to managing inventory, supply chains, and vendor relationships [Ref. 2:p. 5]. Implementation of the Quadrant Model in the civilian sector has demonstrated comprehensive risk management qualities, optimization of personnel resources, and improved material readiness. Table 1 highlights the material attributes of the Quadrant Model.

Table 1.   Material Attributes of the Quadrant Model [From Ref. 3].

Materiel Attributes

	High

Bottleneck (MILSPEC Computers)
- One or restricted sources
- Few options
- Low volume
- Low market capacity
- Low value
- Low substitutability

Critical (Tank Engines)
- One or restricted sources
- Few options
- Low volume
- Low market capacity
- High value
- Low substitutability

Routine (Paperclips)
- Many sources
- Many options
- High volume
- Large market capacity
- Low value
- High substitutability

Leveraged (Spark Plugs)
- Many sources
- Many options
- High volume
- Large market capacity
- High value
- High substitutability

Risk/Uniqueness — High / Low

Low ← **Mission Value** → High

3.   The Critical Quadrant

Most products and inventory items managed in the military have been traditionally handled as critical, indicating their mission essential value to the warfigher. However, in the Quadrant model, both value and uniqueness are assessed together. In the context of the Quadrant model, criticality refers to mission value as well as the characteristics of the supply chain that supports the item.   What differentiates this quadrant from the others is the amount of collaboration and cooperative acquisition and management practices required to provide the smooth, uninterrupted supply of items. The availability, market capacity, and substitutability of items in this quadrant are severely restricted because only a few sources exist, and demand is non-recurring or intermittent.   Additionally, flexibility is also limited due to high man-hour, low automation capabilities of the manufacturers. The critical quadrant, therefore, requires

unique buyer-seller strategic relationships to avoid interruptions in availability and consistent on-demand support.

4. Decision Support

Commercial technology and information science will continue to provide the infrastructure for the operational commander of the 21st century. The widespread use and development of information technology (IT) has increased the overall effectiveness and efficiencies of management practices everywhere. Innovative new uses of IT have decreased the amount of risk uncertainty by minimizing complicated distribution actions as well as maximizing the use of scarce resources to prioritize repair actions. With the correct application of IT, management can tackle the most cumbersome tasks.

The number of IT solutions that is available commercially has dramatically changed the way businesses manage internal and external operations. Decision Support and Intelligent Agent (IA) technologies are already being used in Internet search engines, and have been effectively applied to areas that require large search and retrieval requirements. Expert systems conduct routine and cumbersome operations in complex applications, and their growth and capabilities continue to expand [Ref. 3:p. 4]. Drawing from the positive results drawn to date in industry, there is good reason to believe that IA technology could be used to facilitate collaborative buyer and seller relationships required in the *critical* quadrant while mitigating risk, reducing uncertainties of production and demand, and foster a seamless integration of extensive information. Such belief motivates the research described in this thesis.

B. OBJECTIVES

The objective of this thesis is to determine how Intelligent Agent technologies may innovate the logistical processes associated the critical quadrant, which categorizes materials, products and services that are unique, are high value in terms of cost, and therefore high risk. These materials may only be available from a few sources, are in limited quantities, and require extensive coordination and sharing of information between parties.

C. RESEARCH QUESTIONS

This research focuses on the following questions:

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1. **Primary**

- How can Intelligent Agent technologies be used to implement and coordinate the functions that characterize the c*ritical* cell of the USMC Quadrant Model?

2. **Secondary**

- What is the definition, function, and purpose of the USMC Quadrant Model?

- How does the USMC Quadrant Model improve the effectiveness of Procurement/Contracting, Acquisition Logistics, and Material Management?

- What Intelligent Agent technologies are available to implement the key functions of the Critical Quadrant?

- What limitations may hinder the effectiveness of implementing Intelligent Agent technologies to the Quadrant Model?

D. **SCOPE, LIMITATIONS, AND ASSUMPTIONS**

1. **Scope**

The scope of this thesis is to present the mechanics and functional attributes of the Quadrant Model, specifically focusing on the critical quadrant. All data for this research are derived from published studies associated with the Integrated Logistics Initiative, Lean Sustainment Initiative, and Agile Pathfinders. This thesis analyzes how the critical quadrant functions and what peculiar attributes items have in this quadrant. Additionally, this thesis examines why intense collaborative buyer-supplier efforts are required to ensure successful operation of this quadrant and what IA technologies may improve key functions of this quadrant. Recommendations pertaining to any improvement in the management of the critical quadrant through the use of IA technologies are those of the researcher unless referenced.

2. **Limitations**

The researcher builds upon previous conceptual issues involving management of the Quadrant Model and discusses theoretical approaches of applying IA technologies to the critical quadrant. This thesis does not conduct a process analysis of any specific assets assigned to the critical quadrant or make recommendations for modifying inventory policy or procedures within the Marine Corps. Recommendations are made to further understand the numerous buyer-seller functions that occur in managing the supply chain of the critical quadrant.

3. Assumptions

The researcher assumes that the reader has a general understanding of the mission of the Integrated Logistics Initiative and inventory management policies and practices in the Marine Corps. In particular, the audience for this thesis includes acquisition professionals, material management officers, and logistics and supply officers. It is also assumed that coding and integration capabilities will continue to improve and additional innovations in the area of collaborative data sharing will occur in the near future.

E. RESEARCH METHODOLOGY

This thesis build upon Fowler's Naval Postgraduate School thesis entitled "Innovating the Standard Procurement System utilizing Intelligent Agent Technologies" [Ref. 3]. Fowler used the Davenport Process Innovation model [Ref. 3] to analyze the Standard Procurement System (SPS) and proposed the use of enabling IA technologies to automate key processes. This thesis applies Fowler's methodology and proposes the integration of IA in the Quadrant model, specifically in the critical quadrant where collaborative buyer-seller relationships are necessary to reduce risk and improve overall management of items in this cell. Data are collected from a search of applicable books, studies, journal articles, and other library information resources.

F. BENEFITS OF RESEARCH

This research facilitates Marine Corps decision-making regarding applicable uses of the Quadrant model and the application of Intelligent Agents to conduct redundant managerial tasks for items assigned to the critical quadrant. This research will also benefit operational forces by defining new and innovative means to seamlessly support the warfighters logistical demands.

G. ORGANIZATION OF THESIS

After the introduction, Chapter II introduces the Quadrant Model and its approach to managing items, assets, products and services. Chapter II also details how buyer-seller relationships differ in each of the quadrants and why. Chapter III details enabling IA technologies and their characteristics. Chapter IV introduces the Davenport Methodology to Process Innovation, the Lean Sustainment Initiative and Agile Pathfinders. Chapter V summarizes and provides conclusions and recommendations for further research to enhance the use of IA technologies in buyer-seller relationships.

II. BACKGROUND

A. INTEGRATED LOGISTICS

The Integrated Logistics concept began as a two-phase approach established to review and provide structure to the major logistics processes in the Marine Corps. Phase I concentrated on the consolidation of intermediate and retail supply functions, and is not analyzed in this thesis. Phase II included a series of business case studies, a process analysis of current inventory management techniques at Camp Pendleton, and an analysis of best business practices within commercial businesses. During Phase II, a joint best business practice seminar hosted by Penn State resulted in the development of several key concepts that would improve and enhance buyer-seller relationships, improve supply-chain related functions, and re-classify inventory management techniques. Additionally, Two related logistics case studies involving complex customer-supplier network between industry and government are presented. Objectives in both studies focus on identifying processes in need of greater speed, and more efficient and flexible action through the use of enhanced software tools [Ref. 18].

B. RELATED LOGISTICS CASE STUDIES

1. Lean Sustainment Initiative

In 1997, a collaborative study between the United States Air Force (USAF) and Massachusetts Institute of Technology (MIT) was initiated to analyze growth industries involving constant and competing innovation involving complex operations. Complex in this case is defined as having numerous players involved in designing, production, repair/ overhaul, logistics and delivery for an item. The initial objective focused on strategic collaboration efforts between the aerospace industry and government and how products, services, and responsibilities were delineated. The second objective focused on related efforts in logistics planning, repair operations, and overall life-cycle support. Membership of the study included the Defense Logistics Agency, Raytheon, GE Engine Services, the Air Force Research Laboratory, and Lockheed Martin Aircraft and Logistics Centers. Among the players, three teams were organized with independent objectives. Team One represented the Sustainment Operational Team and their objectives were to conduct research on materials, parts, and issues regarding overall availability. Team Two

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represented the Business Process Team and focused on requirements determination and forecasting. Team Three represented the Enterprise Integration Team and focused on building goals, objectives, and metrics to support means of change for system wide processes [Ref. 18].

LSI's research identified numerous best practices in industry and government. One involved Depot Level Production Operations, which was modeled using the Toyota Production System. As a result of the study, Pratt & Whitney Aircraft have designed and implemented a new, cost-effective framework for system modernization by synchronizing technology and maintenance cycles without interrupting ongoing planned operations. The meticulously coordinated manufacturing system was designed to force closer linkages between all players central to the development, fielding, and life cycle support of a project. The result is lowered depot turn-around times and more efficient forecasting capabilities [Ref. 19]. Secondly, the Corpus Christi Army Depot in Texas created a web-based data collection system that enables visibility and distribution of data pertinent to production operations. The system gives networked customers and suppliers the ability to track operations real time [Ref. 19].

2. Agile Pathfinders

In 1994, Massachusetts Institute of Technology and Lehigh University conducted further research on the aircraft and automobile industries (Vought Aircraft, Ford Motor Company, and General Motors). Their objective also focused on complex customer-supplier relationships, and the ability to deliver specific customer requirements accurately and quickly. Agile Pathfinders used extensive process mapping techniques that identified crucial "transactions". Transactions included activity/cost chains, organization maps, key characteristics, and contact chains between people and companies that occurred during product development. These transactions also had large downstream effects on both the customer and supplier, whether in terms of risk, time, quality, and cost. Computer tools were then used to speed up transactions permitting a more integrated approach in a way that is similar to design for assembly [Ref. 18]. These case studies show that companies in both the automobile and aircraft industries face similar challenges and benefited from similar approaches.

C.   THE QUADRANT MODEL

The fundamental purpose of the Quadrant Model is to classify inventory, products, and services by their uniqueness and value [Ref. 2:p. 3]. The Quadrant Model is a two-by-two matrix that classifies items into four major cells. Each cell implies a different approach to managing inventory, supply chains, and vendor relations. In the military, value is defined as the item's contribution to mission accomplishment [Ref. 2:p. 6]. Today, the Marine Corps manages inventory as if it were all in the "critical" quadrant. Within the commercial sector, however, value is usually defined in terms of contribution margins or profit minus investment [Ref. 6:p. 3]. As a result, inventory is managed according to the dynamics and characteristics of the supply chain, which dictates the level of involvement for supply chain managers. Therefore, items in the "routine" quadrant are handled by exception since there is little product differentiation, high substitutability, and large market capacity. Such items would be owned, managed, and stored by suppliers vice being maintained as on-hand stock within Marine Corps inventory. Consequently, items in the "critical" quadrant require a great deal of collaborative acquisition and management action to provide for smooth, uninterrupted supply of items. Items in this quadrant are severely restricted because only a few sources exist, market capacity is low, and substitutability is unlikely. Figure 1 highlights how repair parts inventory with National Stock Numbers (NSN) were held at the 1st Force Service Support Group, SASSY Management Unit (1st FSSG, SMU).
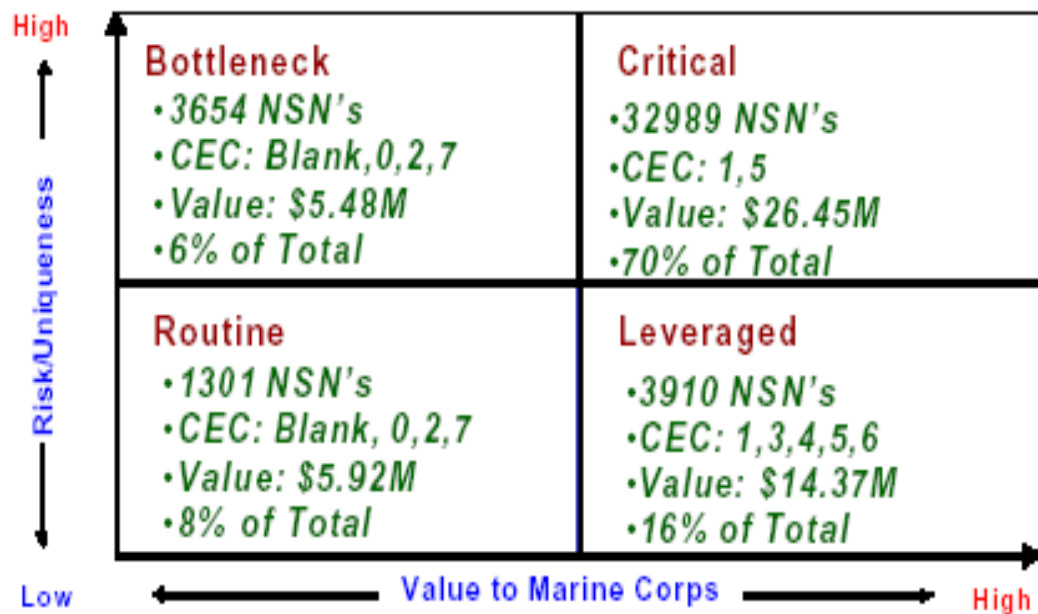
Figure 1.   National Stock Numbers (NSN) Assigned by Quadrant [From Ref. 5].

D.   CRITICAL QUADRANT

This cell poses the most difficult challenge for the supply chain manager. Materials in the critical quadrant may only be available from a few sources. Additionally, these items may be in limited quantities, have unique physical characteristics such as supplier held technology or patents, and have low substitutability. Buyer and seller relationships in this quadrant require a high degree of collaboration and sharing of information to ensure continuous support in uncertain market and demand conditions [Ref. 2:p. 16].   Industries that exhibit these conditions typically manage material that undergoes rapid technological changes and advancement such as high tech electronics equipment of low volume [Ref. 8]. As a result of the dynamics involved in the critical quadrant, most supply chain managers find themselves coping with rather than managing items in this quadrant.

1.   Critical Cell Characteristics

"Critical" cell supply chains are broad and deep, and technological challenges among suppliers and customers range across mechanical, electrical, and materials engineering. This cell accounts for customized, non-standard products such as tank engines and assemblies. These products represent both high value and high risk, which can be further defined in terms of availability, number of suppliers, competitive demand, make or buy opportunities, and substitution availabilities [Ref. 6]. Additionally, such products have unique specification, tolerance, and dimensions characteristics that are available only from a few sources [Ref. 2]. Additionally, there is a low market capacity for these items due to uniqueness and customization to support military specific applications. As a result of the complexity within this cell, acquisition-planning processes must be carefully articulated. Therefore, the careful identification of suppliers for long-term relationships is important to ensure consistent and responsive support.

2.   Vendor Selection and Long–Term Partnering

Due to product uniqueness, the "critical" cell requires careful vendor selection. Accurate demand forecasting, detailed market research, risk analysis, contingency planning, and logistics management are essential to ensure uninterrupted support. Therefore, early supplier involvement and close communications with engineering in the design phase will enable closer, more responsive relationships. Products managed within the "critical" cell share a high degree of complexity that requires closer well-established relationships among suppliers to ensure their ability to respond to demand. Suppliers who specialize in these products must share information and coordinate numerous interdependent tasks in order to produce customized and non-standard products for military unique applications.

Such relationships may extend among numerous suppliers and are "deep" due to integral design processes. Suppliers who survive under these demanding conditions usually have well-established controls for planning, production, and distribution functions. As a result of these relationships, suppliers are better able to forecast, preventing rush and backorders, and can work together to economize. Sources that have

taken advantage of these relationships are more apt to be innovative and continue to invest in cost reduction efforts.

E. INTELLIGENT AGENT (IA) TECHNOLOGY

Cutting edge technologies have taken commerce to a higher level. Internet search engines currently use a form of IA technology in search engines to conduct filtering and data retrieval. Each year, new agents of varying scope and complexity are being introduced that support numerous e-commerce applications. Given the unique dynamics of the critical quadrant, IA technology may help overcome the challenges proposed to the supply chain manager. One example is collaborative technology, which was first commercialized by Mae's Firefly, Inc. Amazon.com uses the technology to inform perspective customers of selections that may appeal to them. The technology uses a preference engine to survey past purchases, and then creates a customer profile [Ref. 9:p. 108].

1. Product/Supplier Differentiation

These agents are designed specifically to help differentiate among suppliers, based on preferences identified through product brokering activities and on product availability. Much of this information can be gained from Request for Proposals and contract solicitation data.

2. Price Negotiation

Auction agents will actually negotiate prices and other terms based on customer and supplier parameters.

3. Substitutability Agents

These agents identify possible substitutes, alternative and emerging technologies or products that have the potential to meet specific customer demands.

F. CLASSES OF AGENTS

There are four primary classes of intelligent agents that are currently being used [Ref. 10:p. 2].

1. Informative Filtering

These agents are specifically enabled to focus on tasks such as filtering E-mail, network news groups and frequently asked questions. Such agents are already being used in commercial application software such as Microsoft Word for Windows.

2. Information Retrieval Agents

Addresses problems associated with collecting information pertaining to commodities such as computer equipment, insurance and advertising, and agents that perform information gathering and delivery.

3. Advisory Agents

Focused toward providing intelligent advice in applications such as electronic concierge, planning and support, financial portfolio management and computer interface assistance.

4. Performative Agents

Oriented toward functions such as business transactions and work performance, marketplace for agent-to-agent transactions, agent negotiation system, automated scheduling, cooperative learning and automated digital services.

G. UNDERSTANDING AGENT FRAMEWORK

To better appreciate how different agent's work, this thesis draws from the work of Gilbert et al. [Ref. 10] and Nissen and Mehra [Ref. 11]. Figure 2 depicts the three basic dimensions of an intelligent agent: collaboration, intelligence, and mobility. Each of the three represents an archetype dimension and functionality [Ref. 3:p. 56]. Note that most expert systems operate at the extreme end of a formalized, expert level of intelligence, but they have not been traditionally designed to be highly mobile or collaborative. Similarly, the mobile remote programming functions of an embedded Java applet can execute program actions but lack expert system intelligence and parallel processing capabilities. Intelligent Agents (IA), on the other hand fall into the middle of the dimension, which gives them good balance of unique capabilities and promising features [Ref. 10:p. 2].
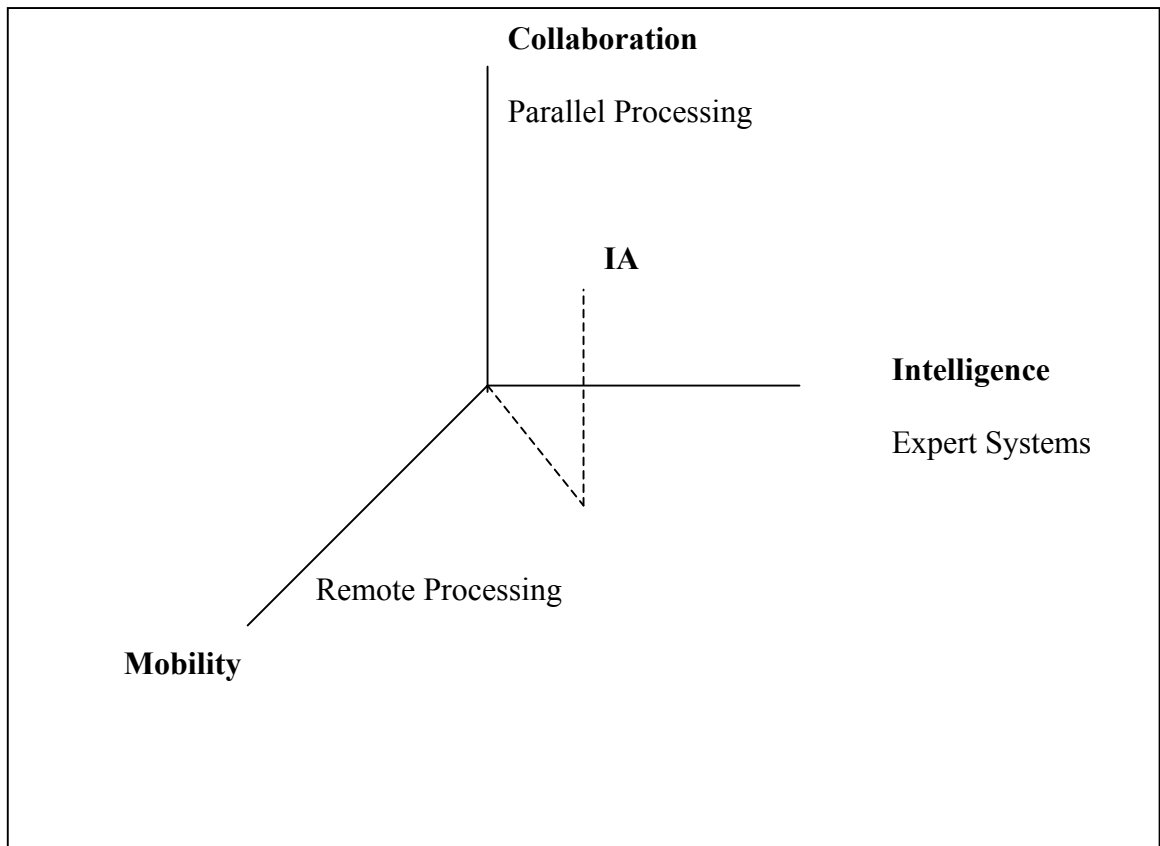
Figure 2.   Agent Framework [From Ref. 7:p. 42].

H.   SUMMARY

The Quadrant Model shows promise in developing a supply chain and buyer-seller relationship that provides utility for the Marine Corps. Due to constrained budgetary and personnel resources, the Marine Corps must develop collaborative strategic relationships with suppliers that facilitate the dynamics required to support items in the critical quadrant, as well as the changing arena of logistics in support of Joint Vision 2010. The features within the Quadrant Model will support unique military supply chains while increasing our ability to project forces globally without diminishing the effectiveness of the logistics chain. Similarly, enabling technologies available through IA advancements show great promise by allowing supply chain managers to manage supplier relationships rather than just coping with external processes and market conditions.

III.   AGENTS IN ELECTRONIC COMMERCE

A.   HISTORY

Electronic commerce encompasses a broad range of issues including security, trust, reputation, law, payment mechanisms, advertising, electronic product catalogs, intermediaries, and back office management. Agent technologies can be applied to any of these areas where a personalized, continuously running, semi-autonomous behavior is desirable.   However, certain characteristics will determine to what extent agent technologies are appropriate [Ref. 11:p. 5].

The proliferation of the Internet has opened up new doors of opportunity for buyers and sellers alike. Its use as a sales and information engine offers an immediate competitive advantage to those who have taken advantage of its global capabilities. However, this growth has come at a price. As more people and businesses take advantage of the "network of networks", the massive amounts of information can create an electronic roadblock for those overwhelmed with its potential. As a result of data overload, researchers have been busy analyzing its impact on users. One of the leading laboratories studying the impact of information overload is Massachusetts Institute of Technology (MIT) Media Labs. They have been dominating IA developments, and have been proactive in seeking agents with advanced capabilities.

One of the first IA applications was designed to sift through information based on a simple criterion: price. Bookworms Bargainbot was designed to find and compare prices from book vendors to include Amazon and Books.com. The agents permitted users to sift through enormous amounts of data comparing price without having to browse among numerous vendors [Ref. 12]. Since then, IA technology has progressed at a rapid rate and new applications are emerging daily.

B.   SPECIFIC AGENT EXAMPLES AND TECHNOLOGY

The current application of IA in commerce has proved insightful and advantageous for the business manager looking to reduce cycle time in decision-making processes. On an advanced level, IA applications exhibit attributes that enable complex decision making capabilities and have proven successful in healthcare, finance, and

marriage counseling situations. Advanced examples include the R1/XCON system, "which has demonstrated professional levels of performance that has met and exceeded those of engineers, physicians, and financial managers" [Ref. 13:p. 89]. The following agents exhibit characteristics and capabilities applicable to the functions within the quadrant model. Such performative applications may prove valuable when examining potential solutions for implementation.

1. Shopping Agents

The type of agent described above is a shopping agent. Its objective is to search out the best online price from numerous sources and compare products. Such agents can be found on-line for vehicles, music, books, and in E-Bay [Ref. 12]. Some of these agents are simple, comparing price only. New agents are becoming more sophisticated and are offering users numerous attributes to include preferences such as warranty information, best borrowing or lending rates, and other customer service type parameters [Ref. 14].

2. Best Value Shopping Agents

Best value [Ref. 14] agents offer the same characteristics as shopping agents, but are also designed to allow customers to choose specific preferences deemed important. Such preferences could be cost, warranty information, customer support after the sale, guarantees, or finding cooperative agreements that return year-end sales dividends based on the total amount spent. These agents permit customers to compare and rate products based on certain value criteria. Such agents are commonly used in areas of high technology such as computer hardware and software sales. These markets have little product differentiation, and technological obsolescence occurs rapidly. Best Value agents also have the ability to compare special deals and promotions from a variety of suppliers, and can notify new potential customers by using previously collected buyer preference information.

20-20Consumer.com [Ref. 14] is using a similar informative value agent. 20-20Consumer.com is an independent consumer comparison-shopping agent that has the capability to sift through hundreds of stores and millions of prices for prospective buyers on a daily basis. The parameters used in this agent are past performance and customer

satisfaction that has been solicited from previous consumer purchases, demands, and similar characteristics.

3. Auction Agents

Another area where IA has proved successful is the Internet auction site [Ref. 14]. On-line auction services offer numerous benefits to the consumer. The agents used in these auctions will notify potential buyers when a pre-assigned request for a particular item has been submitted. When the item becomes available for bidding, potential customers are notified of pending auctions via e-mail. Other options available to potential buyers include information on the seller, such as past performance, customer satisfaction, and overall customer service quality. Currently, the Federal Government has completed numerous auctions with success that have been using agents found in BidTheWorld.Com [Ref. 15]. This agent permits Contracting Offices to post Request for Proposals (RFP) on-line and receive bids real-time. Such agents have been most successful for large bulk purchases of products with little product differentiation. The agent also permits buyers to monitor and track incoming bids, and such services have enabled significant savings over previous proposal and solicitation methods.

4. Kasbah

Kasbah agents are similar to auction agents by proactively seeking out potential buyers and sellers and are established similar to a proxy arrangement. A user who wishes to buy or sell an item simply creates the agent by giving it some direction and sends it to an on-line centralized marketplace. The goal of the agent is to find an acceptable price by a given date to complete the desired transaction. Past performance information is then collected on both the buyer and the seller that is later used in a lineal rating system for future customers [Ref. 11:p. 8].

5. Tete-a-Tete

The Massachusetts Institute of Technology (MIT) Media Laboratories has been developing more sophisticated prototype agents such as the Tete-a-Tete, which is designed primarily for retail sales. Rather than limiting agents capabilities over price and quantity, Tete-a-Tete agents will cooperatively negotiate across a multiple of parameters such as warranties, delivery times, return policies and other merchant valued services. Unique is the agent's ability to unilaterally negotiate with sales representatives using

certain evaluation constraints and parameters to flesh out the best deal, without resource consuming counter-offers [Ref. 11:p. 8].

6. Intelligent Mall

The Intelligent Mall [Ref. 20] is an on-line application that visits virtual stores of authorized vendors on the Internet. Its task is to fill a customers shopping list, and then negotiate purchase with store agents. Once purchases have been made, items are shipped to the customers designated delivery location and the shopping agents account is subsequently charged for all purchases.

C. SUMMARY

This chapter summarizes some of the better-used agents, and articulates their value in an age of increasing information. Intelligent agent technologies have added considerable value for resource-constrained users, especially for those who must work with enormous amounts of data. Additionally, the increasing modularity and ability to fit a unique need makes them more appealing than ever. A combination of different agents can have a positive impact on reducing cycle times and identifying alternative courses of action. Continuing advancements in this area will yield greater flexibility, increased functionality, and will reduce resource intensive operations.

The "critical" quadrant is associated by collaborative buyer-seller strategies that are typically resource intensive and require constant "hands on" management. Intelligent agent technologies have already proven effective by reducing constant human intervention, and have demonstrated expert system type accomplishments. Such agents show promise and can permit smooth functioning of all four quadrants, while simultaneously reducing "hands on" manual intervention. Budgetary constraints will no longer permit the current levels of overhead and manual intervention, and it is imperative that the Marine Corps harness such capabilities and technologies. Although the cost of information will continue to increase, the cost of information technology will decrease making such advancements affordable and achievable.

IV. ANALYSIS OF INTELLIGENT AGENT TECHNOLOGIES

A. OVERVIEW

The researcher follows the methodology of the Naval Postgraduate School thesis work of LCDR David N. Fowler. His thesis, "Innovating the Standard Procurement System Utilizing Intelligent Agent Technologies", systematically looked for opportunities to employ Intelligent Agent technologies. The researcher analyzes key high-level processes and activities within the "critical" cell of the Quadrant model and applies the "Fowler" criteria to determine if the process or activity is a logical candidate for IA applications.

B. THE "FOWLER" CRITERIA

The "Fowler" criteria employed a series of text boxes that linked specific processes and tasks in a linear fashion for the Federal Acquisition Process (FAP). Listed with the task were pertinent attributes, which highlighted specific characteristics involved in each task. Task attributes include four characteristics: Role (e.g., user, contracting specialist, contracting officer), Organization (e.g., supply, agency, contracting office), IT communication (e.g., LAN, WAN), and IT support (legacy systems, commercial applications). The model also lists "feedback loops" (e.g., the process of requiring data to flow back to an earlier point), and "hand offs" (e.g., the process of requiring that an additional participant of higher authority validates the decision) [Ref. 3:p. 78]. Figure 3 highlights a process flow with task attributes.
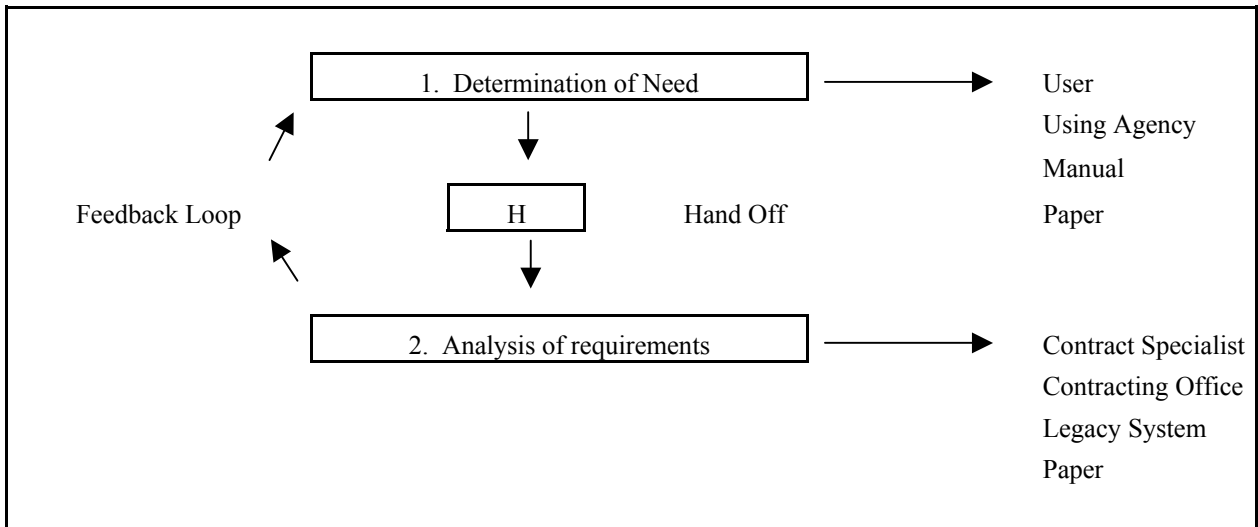
Figure 3.   Process Flow with Task Attributes [From Ref. 3].

Once the process flows were developed, a baseline summation was used to determine if the process is currently automated by the Standard Procurement System (SPS). Automated tasks were assigned an "+", a "0" if SPS only supports the function, and a "- " was used if no automation exists [Ref. 3:p. 79]. Table 2 summarizes the results of this step in the "Fowler analysis of SPS.

Table 2.   SPS Functions and Outcomes using Fowler Criteria [From Ref. 3].

FAP Function	SPS Performs?	Grade
A. Determination of Need		
1. Forecasting Requirements	0	0
2. Acquisition Planning	-	-
3. Purchase Request	-	-
4. Funding	0	0
5. Market Research	+	+

The remaining candidates were further analyzed to determine to what degree could each function be an IA innovation candidate by answering the following questions:

- Does SPS automate the function well and need improvement with IA?
- What is the potential benefit for automating the function with IA? [Ref. 3:p. 90].

Similarly, another table was used to grade FAP processes. Positive responses to the questions were assigned an "+", neutral or undetermined responses were assigned and "0", and negative responses were assigned a "-". Table 3 summarizes the results of this step in Fowler's analysis of SPS.

Table 3.   Grades from Questions 1 and 2 [From Ref. 3].

FAP Function	Question 1	Question 2	Grade
A. Determination of Need			
1. Forecasting Requirements	0	0	0
2. Acquisition Planning	-	+	0
3. Purchase Request	-	0	-
4. Funding	0	+	+
5. Market Research	+	+	+ +

The next step combined the results from both tables, equally weighting each grade. The simple summation of these grades range from "- - " (e.g., both questions 1 and 2 are rated "-") to "+ +" (e.g., both questions 1 and 2 are rated "+"). Table 4 summarizes the results of this step in Fowler's analysis of SPS.

Table 4.   Summation Results [From Ref. 3].

FAP Function	Question 1	Question 2	"Step 1" Grade
A. Determination of Need			
1. Forecasting Requirements	0	0	0
2. Acquisition Planning	-	-	--
3. Purchase Request	-	0	-
4. Funding	0	+	+
5. Market Research	+	+	++

The final step of the "Fowler" criteria combined the results of both tables identifying the frequency of occurrence and grade. Table 5 provides a summary.

Table 5.   Summary by Frequency and Grade [From Ref. 3].

Frequency	Grade
6	++
15	+
41	0
15	-
1	--

All Processes were subsequently graded, and those without a "++", "+", or "0" grade were eliminated as potential candidates for IA application.   In the following section, the researcher will use the "Fowler" criteria to assess if IA technology is a logical candidate for the Quadrant model.

C.   DESIGNING A HIGH-LEVEL PROCESS

Since the top-level mission of the "critical" cell relies on the development of collaborative and strategic vendor relationships, the researcher develops a high-level vendor partnering process model. Such relationships must be able to support demand and deliver a product that meets the needs of the user.   Therefore, the initial step in

developing a process vision starts with the user's requirements (requirements determination). Included in each process are task attributes. Each process contains four of the following characteristics derived from the "Fowler" criteria: Role (e.g., user, program office, contracting office, supply officer), Organization (e.g., program office, contracting office, wholesale, intermediate or, organic level supply), IT support (e.g., legacy system, commercial application), and IT communication (e.g., LAN, WAN). A high-level process for vendor partnering is provided in Figure 4. Note that the whole process is iterative and non-linear, and sharing of information is assumed and occurs throughout the process with feedback loops and handoffs occurring in a similar fashion.
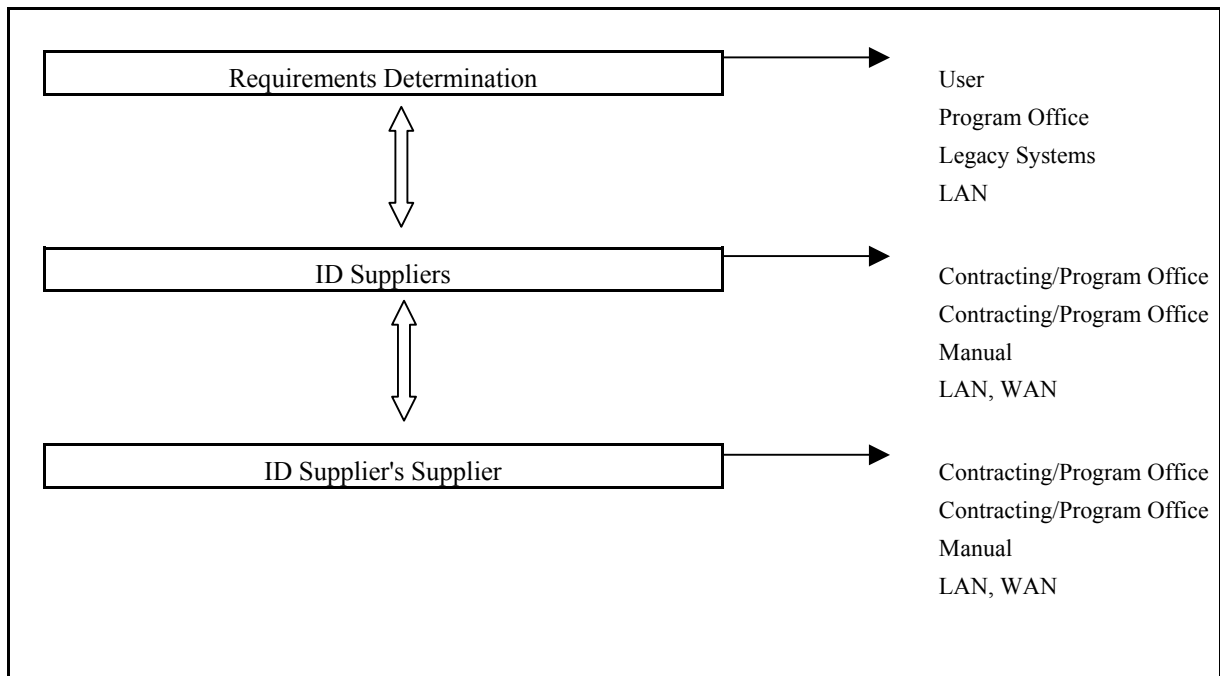
Figure 4.   High-Level Process for Vendor Partnering.

The next step of the "Fowler" criteria determines if information technology is used to automate functions among processes and task attributes. As discussed earlier, automation was accomplished using the Standard Procurement System (SPS). However, the Marine Corps currently employs over 140 logistics systems, none of which currently automates the processes in Table 3 [Ref. 3:pp. 7-39]. Table 6 provides a summation of attributes and grades.

Table 6.   USMC Logistic System Functions and Outcomes using Fowler Criteria.

Process Attributes	Current USMC Environment	Grade
A. Requirements Determination		
1. Acquisition Planning	0	0
2. Market Research	0	0
B. Identify Suppliers		
1. Production Capacity	-	-
2. Design Capacity	-	-
3. Linking Key Processes and Activities	-	-
4. Technology Sharing Capabilities	-	-
C. Identify Supplier's Supplier		
1. Production Capacity	-	-
2. Design Capacity	-	-
3. Linking Key Processes and Activities	-	-
4. Technology Sharing Capabilities	-	-

(0) = Current Logistics Systems only Supports

(-) = Current Logistics Systems does not Automate and Support

Table 6 indicates a "0" grade for 2 functions. Current USMC logistics systems do not fully automate these steps, but the systems do support that acquisition function. These systems typically have either management level or user level reports that are generated to assist in meeting specific Acquisition needs.

The process attributes are further analyzed to determine to what degree each function may be an IA innovation candidate by answering the following questions:

- Does the current USMC logistics environment automate function well and need improvement with IA?

- What is the potential benefit for automating the function with IA? [Ref. 3:p. 90].

- Similarly, another table is used to grade processes attributes. Positive responses to the questions were assigned an "+", neutral or underdetermined responses were assigned and "0", and negative responses were assigned a "-". Table 7 provides a summation of this process.

Table 7.   Grades from Questions 1 and 2.

Process Attributes	Question 1	Question 2
A. Requirements Determination		
1. Acquisition Planning	0	+
2. Market Research	0	+
B. Identify Suppliers		
1. Production Capacity	-	+
2. Design Capacity	-	+
3. Linking Key Processes and Activities	-	+
4. Technology Sharing Capabilities	-	+
C. Identify Supplier's Supplier		
1. Production Capacity	-	+
2. Design Capacity	-	+
3. Linking Key Processes and Activities	-	+
4. Technology Sharing Capabilities	-	+

The next step combined the results from both tables, equally weighting each grade. Table 8 provides a summation of this process.

Table 8.   Summation Results.

Process Attributes	Question 1	Question 2	Step 1 Grade
A. Requirements Determination			
1. Acquisition Planning	0	+	+
2. Market Research	0	+	+
B. Identify Suppliers			
1. Production Capacity	-	+	0
2. Design Capacity	-	+	0
3. Linking Key Processes and Activities	-	+	0
4. Technology Sharing Capabilities	-	+	0
C. Identify Supplier's Supplier			
1. Production Capacity	-	+	0
2. Design Capacity	-	+	0
3. Linking Key Processes and Activities	-	+	0
4. Technology Sharing Capabilities	-	+	0

The final step of the "Fowler" criteria combined the results of both tables identifying the frequency of occurrence and grade. Table 9 provides an example.

Table 9.   Summary by Frequency and Grade.

Frequency	Grade
0	++
2	+
8	0
0	-
0	--

The results from Table 9 indicate that only 2 functions require consideration for innovation using IA technologies. Process attributes A.1. and A.2. (i.e., acquisition planning, market research) receive a "+" grade because the current logistics systems do not automate and perform either acquisition planning or market research. Current logistics systems can, however, manually process data if manipulated by the user. Therefore, they are strong candidates for innovation. The remaining 8 functions receiving a grade of "-" are eliminated.

D.   INCORPORATING IA TECHNOLOGY

The final step requires the incorporation of IA technologies. Recall from Chapter III that various agents can be tasked to support both acquisition planning and market research functions.

Acquisition planning requires the review of acquisition histories and includes the identification of data from catalogs, periodicals, and on-line sources which include prices and availability [Ref. 3]. Agent technologies that can support these processes include market research agents. Such agents can be tasked to perform data search and retrieval as well as price comparisons. Such technology offers potential opportunities without the need for intensive manual evaluation and comparisons. A market research agent can assist in initial make or buy comparisons by searching the web for information required to support specific attributes set by the user. Such information can assist in the initial acquisition planning phases by also identifying specific key characteristics of suppliers. Use of market research agent technologies is consistent with designing strategic partnerships to support "critical" cell products and services.

Successful product management within the "critical" cell of the Quadrant model requires vendors to maximize competitive advantage by investing in relation-specific programs that lower cost, improve quality, and speed product development. Product management includes such processes as inventory reduction and using a streamlined demand-pull type system, and processes such as networked product development systems that permit a better picture of upstream and downstream supply chain dynamics and functions. Such processes could eventually include efforts to move "critical" cell products, which are integral, to a more modular approach. A modular product is a complex product whose individual elements have been designed independently and yet function together as a seamless whole [Ref. 21]. A combination of performative and advisory agents could assist in this area. Such agents can be assigned attributes to find these conditions such as degree of information sharing, continuity of and types of among co-suppliers, and investments in relation-specific programs.

E.   SUMMARY

This chapter examines high-level processes within the "critical" cell of the Quadrant model and makes recommendations for applying IA technologies using the "Fowler" criteria. Agent technology has the potential to reduce the amount of manual intervention required to support functions within the "critical" cell. With the growing proliferation of networked technologies and communications, IA technology poses a viable solution for the supply chain manager to help build collaborative relationships. Intelligent Agent technology is a feasible solution to support acquisition planning and market research and support decision-making processes. As IA technology progresses, many of the manual decision making processes can be eliminated, allowing the supply chain manager to focus on strategic supplier management. Additionally, IA can assist the vendor selection process by identifying suppliers who have developed infrastructures that support "critical" cell processes.

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V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

The primary objective of this thesis is to propose the use of intelligent agent (IA) technologies in the "critical" cell of the USMC Quadrant model. The research conducted in Chapter III reveals potential benefits using this technology. Although some of the current technology remains in its infancy, new value added attributes of IA technology will inevitably grow as new e-commerce advancements occur. It is important to remain proactive in this area of research, especially as new methods to support Internet enabled business platforms proliferate.

The primary research question of this thesis addresses how IA technologies could be used to implement and coordinate the functions that characterize the "critical" cell of the USMC Quadrant model. Using the "Fowler" criteria model, the researcher develops a high-level process model depicting various attributes and functions within the "critical" cell. Each process is subsequently graded following the above criteria and analyzed according to possible IA candidacy.

Through this research and analysis, two specific IA applications are considered for innovating the Quadrant model, performative (market research) and advisory agents. Both types of agents represent similar functionality that is currently used in Internet search and retrieval engines. These agents offer supply chain managers an automated tool to assist in acquisition planning and market research functions.

This research concludes that intelligent agent technology is capable of automating and reducing manual intervention to support market research and acquisition planning functions within the "critical" cell of the Quadrant model. Additionally, this thesis also provides other generalized conclusions. In particular, IA technology can already be successfully implemented to support tasks within the "routine" cell of the Quadrant model. As explained in Chapter II, the "routine" cell is characterized by low value, low risk items that have high substitutability and are widely available. Such items are available from numerous vendors and have little product differentiation. Numerous agent technologies, such as best value, auction, and intelligent mall agents, could be

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successfully employed to alleviate manual intervention requirements. Such agents could initially be assigned to compare specific attributes such as price, quantity, special deals, and promotions from a variety of vendors. Auction agents could then be employed to conduct reverse auctions among suppliers who meet the initial requirements of the user. Attributes assigned to the final selection processes may include best price, warranty, and customer service variables.

B.   RECOMMENDATIONS

Based on the conclusions, IA technologies appear to offer potential for improving the effectiveness of the Quadrant model. However, before this is accomplished, the researcher recommends that future efforts be focused specifically on defining the complex processes involved in the "critical" cell. This can be accomplished through a detailed process analysis of the crucial interactions among people, products, and services among all DoD customers, users, and the commercial market. A process analysis must be modeled around core business functions and should enumerate major processes. The focus of effort should include modeling "as is" processes that support the numerous classifications of equipment that fall within the scope of the "critical" cell. Such items include major weapon system components and assemblies, communication and information technology systems, and various engines and transmissions. The concept should be developed and modeled using existing business "templates" that mirror or provide similarity in product design and integration. The evolution of the American automobile industry supply chain and production processes may offer useful procedures and metrics for accomplishing this task.

C.   FUTURE RESEARCH

There is no doubt that opportunity for success will only be enhanced by the next wave of Internet and IT enabled commerce. In general, both the Internet and information technologies will continue to challenge, change, and transform how industry relations are managed. Local and wide area networking has already linked customers, users, and industry and has greatly affected the growth and prominence of supply chain management. Therefore, it is equally important for the supply chain manager to understand how companies like E-Bay and Yahoo manage their supply chains. Both companies have integrated and harnessed immense power from IT advancements, and

understand exactly what their customers need and want. They are building "trust" relationships, and are built by solving problems. Such relationships focus on solving problems finding the right mixes of products or services that exceed customer expectations. Marine logisticians, contracting officers, program managers and supply officers must develop this type of relationship with our warfighters.

1. Cooperative Sponsorship Program

By working with acquisition and contracting students at NPS, the Integrated Logistics Office (ILC) can support its mission by identifying various research projects tailored to answer specific questions. Such projects should proactively support concepts employed by Integrated Product Teams (IPT), such as harnessing students from various curriculums to include IT. These teams should also be given wide latitude of scope, using "brainstorming" techniques. Additionally, these teams should be permitted to implement various process analysis techniques that are employed in companies that have proven successful track records of change and innovation.

2. Internet Enabled Business

In addition to conducting process analysis studies on products and services, there is also a need to understand the importance of command and control relationships. Changes today are occurring as a result of knowing what is working and what is not working when information technology is added. It is equally important to understand how sophisticated companies are built and destroyed from the application of IT. Before tons of appropriated dollars are laid down, lessons learned from top tiered IT firms must be closely examined. The Marine Corps must balance speed and efficiency, and must have contingency plans to fall back on. IT marketing has led to a lot of hype, which has consequently caused many ventures to fail from the start. Therefore, it is important to carefully examine the successful qualities of Internet enabled businesses and determine its application to our core business. The Marine Corps must not succumb to the pressures of E-business when determining the future direction of our Corps.

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