Case study

Quality communication within a connected manufacturing supply chain

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Keywords

Case studies, Supply chain management, Quality, Communication

Abstract

Analyzes four entities in a connected supply chain through a case study. Focuses on the relationships between organizations and the specific goals and objectives of each firm. The study was conducted from an insider's view through personal experiences, and a series of on-site and telephone interviews with managers from each entity of the supply chain. Focuses on passing on and interpreting quality goals, alignment of quality goals and the existence of partnership with the connected supply chain. The main reason for the success of the supply chain is the strength or dominance of the manufacturer. Strong and frequent unidirectional communication exists between the manufacturer and the supplier and between the manufacturer and the distributor. These connections are the crux of the supply chain. From this strong relationship, the supply chain is able to remain successful while communication weakens and disappears at either end of the supply chain.

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Introduction

The intent of this research paper is to analyze, through a case study, four business entities in a connected supply chain whose final products are life safety systems. The case study particularly focusses on the relationships between the organizations and the specific goals and objectives of each firm. Research for this study was conducted from an insider's view through personal experiences, and a series of on-site and telephone interviews with managers from each entity of the supply chain. The supply chain studied in this paper is shown in Figure 1.

In an attempt to focus the study specifically on the relationships between the entities within the supply chain, three specific research questions will be examined throughout the course of this paper:

(1) How are quality goals passed and interpreted at different levels in a connected manufacturing supply chain?
(2) Does alignment of quality goals determine success of an entire supply chain?
(3) Do true partnerships exist in a connected supply chain?

Through observations based specifically around these three questions, a clear picture of the relationships within this supply chain will emerge.

The parent company of this supply chain, although willing to be interviewed and willing for this article to be published, asked not to be identified. They are a large, diversified manufacturing and service company with locations in over 100 countries around the world. The parent company is a large supplier and service provider of life safety systems, with revenues exceeding $25 billion.

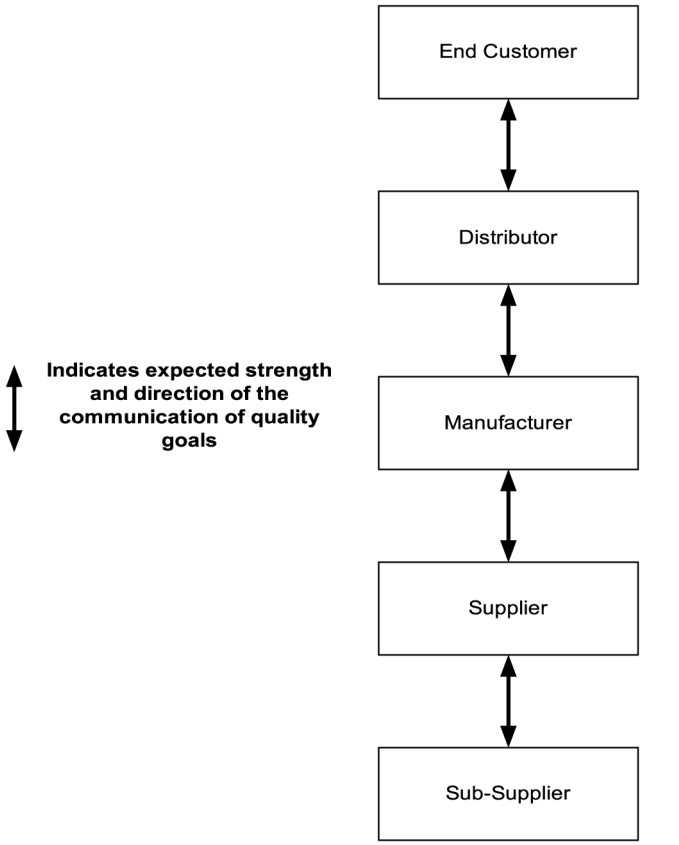
The distributor in our supply chain is the sales and service entity. Newly established from a merger, the distributor provides the customer contact in the chain. With locations throughout North America, the distributor provides service by utilizing over 10,000 installers, technicians and professionals.

The manufacturer in our supply chain employs over 1,000 people and manufactures the complete life safety system. The life safety systems are manufactured and sold under the distributor's brand name and 100 percent of the systems manufactured at the manufacturer are sold to the distributor.

The entity in the supply chain that is the immediate supplier to the manufacturer is an electronics manufacturer that we will call the supplier. The supplier is a privately held, family-run company with annual sales of $4 million. The supplier employs 50 employees and has been a supplier of customized printed circuit board

Supply Chain Management: An International Journal
Volume 9 · Number 4 · 2004 · 323-330

Figure 1 Predicted life safety system supply chain



assemblies to the industry and the manufacturer for 40 years. One-third of the supplier's sales are attributed to the manufacturer for use in their life safety systems.

The direct supplier to the supplier will be called the sub-supplier. The sub-supplier has annual sales of $2 million and employs 26 people. The sub-supplier has been in business with the supplier for over four years. The sub-supplier manufactures printed circuit boards for the supplier. Only 4 percent of the sub-supplier's sales are attributed to the supplier. The sub-supplier does not consider the supplier to be a major customer.

Literature review

It is presumed that an organization does not exist within a vacuum, but within the context of a supply chain. The individual success of an organization has become increasingly dependent on the efficient functioning of its supply chain, with one common focus on quality. For the purpose of this paper, a supply chain is described by Ross (1998), who states:

> Satisfying the end customer can only take place when the entire supply channel from materials supplier to retailer are linked closely together in the pursuit of innovative ways to improve service value, reduce channel costs, and create whole new regions of competitive space. In today's global economy, it has simply become impossible to service the final customer successfully each and every time if the links in the supply channel that precede it are not also driven by the same focus on quality and value-added activities.

This paper will determine whether the end customer is serviced successfully through the entities in their supply chain that are theoretically closely linked, and whether the entities have similar quality goals. In order to understand how quality is communicated in a connected manufacturing supply chain, we must go beyond a simple definition and recognize previous research.

An anonymous article in *Purchasing* (1990) discusses tracking quality through the supply chain. The article focuses on the relationship between the customer, AT&T, and their supplier, Intel. AT&T specified a 99.8 percent acceptance rate for its suppliers, which corresponded to asking Intel to increase its quality standards by 1,500 percent. In order to meet the standard, Intel decided to take a leadership role with its suppliers and put together a supplier quality improvement program that focused on six standards:

(1) regular communications with suppliers;
(2) continual and frequent forecasting of product requirements for suppliers;
(3) a commitment to place all orders within agreed-on lead-times;
(4) timely database reports on quality statistics;
(5) timely materials returns to suppliers for failure analysis; and
(6) a process to implement and monitor corrective actions.

Intel began to hold its suppliers to the same quality standards set for them, and started a "ripple effect" in the supply chain. Our study will examine similar supplier relationships by looking at how quality goals are passed through different levels in the supply chain.

Cooper and Yoshikawa (1994) studied a three-firm supply chain in the Japanese automobile industry that demonstrates the blurring of organizational boundaries. The study identified the use of inter-organizational cost management systems within the supply chain to improve coordination and efficiency. The firms within the supply chain not only shared cost information, but also information on production and quality control, research and development findings, and the use of new materials and technologies. The sharing of information among these firms demonstrates the push to adopt horizontally-integrated organizational structures between the

Supply Chain Management: An International Journal
Volume 9 · Number 4 · 2004 · 323-330

firms to increase contact between manufacturing and the customers. This allows the supply chain to become more flexible and adaptable to changes in the environment. The case study provides thought-provoking research into integrated management and multidirectional communication within a supply chain. Similar to Cooper and Yoshikawa, our study will analyze the communication of quality goals within a connected supply chain.

Based on data from 215 North American manufacturing firms, Narasimhan and Jayaram (1998) examined causal linkages in a supply chain. The article addressed three major questions:

(1) Do sourcing decisions affect the degree to which firms achieve manufacturing goal of cost, flexibility, dependability, and quality?
(2) Does the degree of manufacturing goal achievement lead to higher customer responsiveness?
(3) Does the degree of manufacturing goal achievement lead to higher internal manufacturing performance?

The study found a statistical significance between the variables in all three questions. Therefore, it was concluded that, together, all three questions imply that supplier integration, strategic integration and customer integration across the supply chain determine customer responsiveness. Our study will build on these three key components and examine quality goal alignment in a connected supply chain.

Mangiameli and Roethlein (2001) documented how four different entities impose quality requirements on each link of a connected manufacturing supply chain. Their findings recognized the need for multidirectional quality awareness. Our study, similar to theirs, will determine whether alignment of quality goals determines the success of an entire supply chain.

Roethlein *et al.* (2002) studied 634 US manufacturing plants to determine whether there were differences in the implementation of quality management practices between base-level suppliers, subcomponent suppliers, component suppliers, major component suppliers and end-product producers. In their study, quality management practices were found to be similar within different levels of a supply chain. Our study investigates whether or not similar quality goals exist within a connected supply chain.

Birch (2001) suggests using a supplier classification or rating system in selecting and evaluating suppliers. The article discusses setting strict parameters for three different levels of suppliers (groups A, B, and C). The A group of suppliers would be those that meet the highest expectations and criteria and those that a long-term relationship, partnership or alliance should be built with. Suppliers that did not meet all of the criteria would be classified as B or C, depending on their qualifications. Birch sees this classification system as an effective way to manage a supplier base. Our study will determine whether true partnerships (with group A suppliers) exist between different entities in the supply chain.

Wisner and Tan (2000) surveyed purchasing and materials managers across different US manufacturing industries on current supply chain management practices. Their study discovered important supplier conformance issues among the different industries such as implemented quality policies and documented systems, maintaining adequate inspection and testing equipment as well as investigating non-conformance causes and taking corrective action. Their results also identified that over 60 percent of the respondents indicated that they had a formal supplier partnership or strategic alliance program in place. Our study will examine the issue of supplier partnerships in a specific manufacturing supply chain.

Methodology

The research methodology used in this case study was developed through a series of on-site and telephone interviews with top managers from each entity within the chain during the summer and fall of 2001. The interviews consisted of open-ended discussions based on a structured set of questions. The questions were directed at understanding the quality and manufacturing goals that existed within the organizations as well as the methods used in each level of the supply chain to achieve these goals, and the relationships that exist between these connected entities. A total of four on-site interviews and one telephone interview were conducted with individuals from the entities referenced in Figure 1. Interviews ranged in length from 45 minutes to two hours. Personal interviews were conducted with managers whose titles included Director of Quality Assurance, Manager of Quality Systems, General Manager, Director of Business Development, and District Service Manager. All interviews were recorded and transcriptions of each interview were made. Follow-up phone calls were made to clarify certain points.

Observations

The information reported in this section consists of views and observations of each individual

Supply Chain Management: An International Journal
Volume 9 · Number 4 · 2004 · 323-330

interviewed within the organizational entities in the supply chain, which are presented from the perspective of each entity.

Distributor

The distributor (see Figure 1) is the entity in the supply chain responsible for the sales and service of the life safety systems. The distributor is the only entity within the chain that communicates directly with the end customers. Although the distributor and the manufacturer both operate within same division of the parent company, the two companies remain independent of one another with no integrated management. The distributor purchases all its products from the manufacturer and then sells the products to the end commercial customer. The distributor is also responsible for all of the service and preventative maintenance required by the life safety systems.

The distributor communicates with the customers through their autonomous branches. The service staff within each branch consists of a District Service Manager who is responsible for the operations of that branch, Technical Representatives who are responsible for the actual maintenance and service of systems, as well as one or more dispatchers and inspectors, depending on the size and structure of the particular branch. In dealing with life safety equipment, maintenance and service is essential.

As reported by the District Service Manager of the distributor, customer contact is a daily occurrence. Technicians are constantly in the field interacting with customers in order to fix or maintain their systems. The Branch Service Manager also meets with customers on a regular basis in order to build relationships and establish trust. The District Service Manager visits approximately five customers per week. Even though communication is open and frequent between branch personnel and customers, the District Service Manager stated that quality is rarely discussed. He stated that he would gladly listen to customer's quality concerns, requirements or suggestions regarding life safety systems, although customers are not specifically asked about these aspects of quality. Conversations with customers focus mainly on factors affecting the service quality of the systems.

The goal of the distributor, as communicated by the District Service Manager, is customer satisfaction. He believes that quality is system dependability, reliance, and product assurance. Quality emphasis within the distributor is placed on the functionality of the entire system. Quality numbers and statistics are of little use or importance to the District Service Manager or his technicians, who are faced with system failures and malfunctions every day. The technicians see quality as the opposite of failure: their quality goal is to prevent system failure or, when failure does occur, to restore the system to its proper functionality. These quality goals, established by the distributor, are unique to the distributor and are not communicated to the manufacturer. Although the distributor is responsible for both sales and service of the life safety systems, they are not involved with the process of designing or manufacturing the systems and therefore have no impact on product quality.

When asked how a branch communicates customer quality requirements or preferences to the manufacturer for incorporation into the manufacturing process, the District Service Manager responded, "I don't know if I even do that. I don't know. That one I don't have an answer for . . .". Although the branches have several channels through which to communicate with the manufacturer, such as customer service and technical support, there is no system through which customer quality issues and expectations can be communicated. Interactions between the distributor and the manufacturer are frequent, even though the District Service Manager does not consider their relationship to be a partnership.

Manufacturer

The manufacturer in this supply chain (see Figure 1) manufacturers life safety systems that bear the distributor's name. All products produced by the manufacturer are sold directly to the branches of the distributor, although the manufacturer considers the end-users to be its ultimate customers. The manufacturer has a formal quality system in place. The company has a structured total quality management and continuous improvement system as well as an elaborate statistical process control program. The company has been ISO 9001 quality certified since 1994.The manufacturer has an extensive vendor approval process, a report card and corrective action program that continually monitors supplier performance, as well as established supplier metrics to monitor whether a supplier moves into the marginal area and needs attention. The company regularly visits supplier sites and constantly communicates with its vendors, mainly through the purchasing department.

Quality goals and initiatives within the supply chain originate through upper management at the manufacturer. Although vague financial goals are disseminated from the corporate division of the manufacturer, such as a 25 percent increase in earnings before interest and taxes, it is the manufacturer's management that initiates specific quality objectives. Efforts to achieve quality goals

Supply Chain Management: An International Journal
Volume 9 · Number 4 · 2004 · 323-330

are initiated through internal improvements and are communicated to suppliers only if a customer problem specifically relates to a supplier issue. The manufacturer is currently focused on two specific quality objectives, i.e. to drive down warranty replacement numbers and failure rates. In order to meet these objectives, the company has established a high-volume assembly (HVA) project as a means to improving product quality and reducing failure rates. The HVA project is carried out by the quality assurance, quality control and engineering departments. Returned defective warranty replacement items are analyzed in order to identify manufacturing-related problems. Suppliers are not made aware of identified problems or solutions. All quality information remains internal. The manufacturer does not consider any of its suppliers to be business partners.

Supplier

The supplier in this supply chain (see Figure 1) is a finished-good supplier to the manufacturer. Many of the supplier's products (customized printed circuit boards) are never seen by the manufacturer, but are shipped directly to customer sites to be installed into the life safety system. The supplier has a close working relationship with the manufacturer owing to level customization of their products. Many of the finished goods that are supplied by the supplier have custom graphics that are specifically tailored for the individual end customers. The supplier installs many of the manufacturer's specifically tailored printed circuit boards into their products.

The relationship and communication between the manufacturer and the supplier occurs mainly through the purchasing department at the manufacturer and sales personnel and upper management at the supplier. The supplier receives no formal quality training from the manufacturer. The manufacturer communicates its quality requirements and expectations to the supplier through product specifications and through a corrective action system. If there is a problem that the manufacturer recognizes, the supplier will be assigned a corrective action and given a specific amount of time to fix it. According to the supplier's Director of Business Development, the corrective action is never just assigned by the manufacturer, it is always discussed and solutions are developed jointly. Through this process, the manufacturer becomes involved with the quality and training of the supplier, although there is no formal program. Quality communication seems to exist informally and only when needed. However, both companies feel as though this is adequate and effective.

According to the Director of Business Development, the supplier does consider the manufacturer to be a business partner. He characterizes their relationship as follows:

> I would consider our relationship a partnership. If I've ever had any problems, if I ever needed something, if I ever needed a price point, [the Manufacturer] is always willing to use their purchasing power to assist me in getting what I need. [. . .] I would have no ground to stand on if I said this relationship wasn't a great relationship because I've never asked a question and not gotten an answer. The only thing and I'm working on it right now is future business. There's not a clear picture with [the parent company] how you get future business . . . (Director of Business Development transcript, 2001).

However, in looking at the relationship strictly from the supplier's point of view, the Director of Business Development does see that the manufacturer is a bit hesitant to commit to a partnership or sole supplier relationship. The manufacturer does carry competitors' lines of similar finished goods, which causes the supplier to feel as though the manufacturer does not completely believe in their company.

The supplier does have a clear quality policy, which focusses on change and responsiveness. The Director of Business Development believes that quality at the supplier is driven by outside factors and is mainly customer-focused. The company is ISO 9000 quality certified, does have a formal continuous improvement program and quality council as well as an approval process for new vendors. The supplier has also taken the corrective action system applied to them by the manufacturer a step further, and now assigns corrective actions to its suppliers.

The Director of Business Development does not deem the suppliers to the supplier (sub-suppliers) to be business partners. Although the company is working towards partner relationships with its suppliers, he does not feel that the company is there yet.

Sub-supplier

The sub-supplier in this supply chain is defined as the supplier to the supplier (see Figure 1). The sub-supplier supplies a very standardized printed circuit board to the supplier which is used in the production of their finished products that go into the life safety system. The General Manager of the sub-supplier was unaware that their products eventually became part of the life safety systems. He was also not informed of any quality requirements or specifics imposed by the manufacturer.

The sub-supplier does not have a formal quality system in place. Continuous improvement efforts do exist within the organization whenever possible, although no official program has been

Supply Chain Management: An International Journal
Volume 9 · Number 4 · 2004 · 323-330

implemented. The General Manager stated that his company is not quality certified owing to cost reasons and the size of their organization. The sub-supplier does follow some internal statistical process controls, although nothing has been documented at this point.

The General Manager describes quality within their organization as "giving the customer the best product at the best price [...] basically just manufacturing per spec or per print". The sub-supplier relies on their customers to communicate their needs. The General Manager believes that their customers communicate their needs through product specifications and prints, which the sub-supplier will do its best to accommodate.

The relationship between the supplier and the sub-supplier is characterized by open communication. Communication mainly exists through the purchasing and quality department at the supplier and the management at the sub-supplier. The supplier provides no quality training to the sub-supplier, and specifies their manufacturing requirements through blueprints. The sub-supplier imposes their internal quality standards unless otherwise specified.

The General Manager of the sub-supplier does not consider the supplier to be a business partner. He characterizes the relationship between the two organizations as a "mutual working relationship". The sub-supplier is satisfied with their current relationship with the supplier, which is based on open communication and small accommodations allowed by the process.

Summary and conclusions

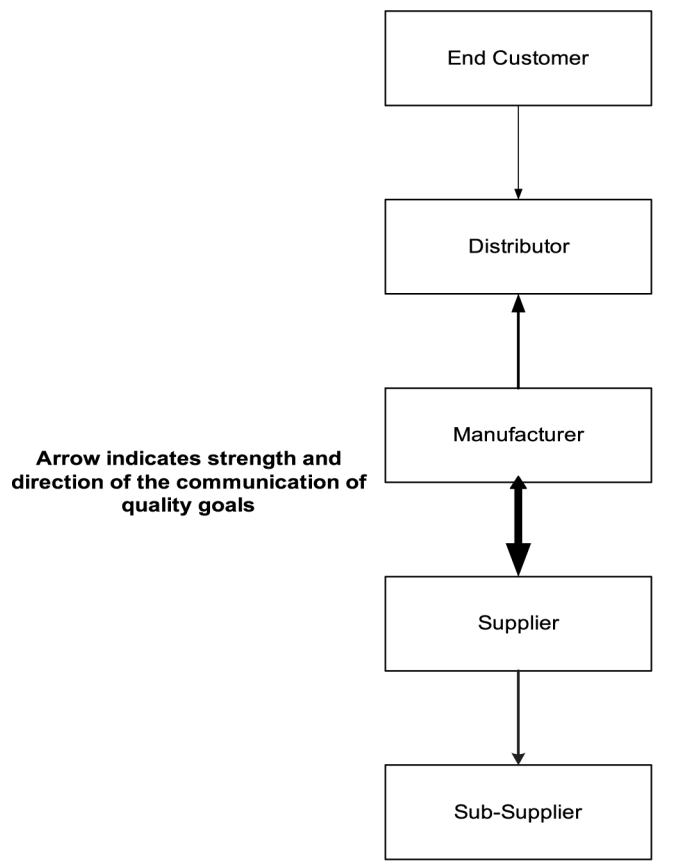
This case study has shown how four different entities within a manufacturing supply chain interact with each other. Each entity presented has unique manufacturing, quality and corporate goals, none of which were consistent throughout the chain. The supply chain was found to have no integrated management or goal alignment. Although the ultimate goal of some entities was customer satisfaction or end-customer satisfaction, this was not constant throughout the chain, and nor were customer preferences identified to all entities. True partnerships did not exist in this connected supply chain. Working relationships and continual business contracts (rewarded after consistent product shipments) seem to be the norm.

There was a dominant downward influence on the chain by the manufacturer owing to their size, manufacturing ability and monetary authority. However, this influence did not seem to extend beyond the supplier entity in the supply chain. Some relationships between the entities in this chain were extremely strong and were characterized by open, unidirectional communication, while other relationships were extremely one-sided. These simplifications will be further analyzed by examining the relationships between the entities presented in Figure 2. Figure 2 represents the strengths of the relationships and degree of communication between the entities through the thickness (and direction) of the arrows, and will be used as a model to further develop the case study findings. A summary of the key findings between each of the links in this connected supply chain follows.

End customer-distributor

- Relationship characterized by frequent communication, built on respect and trust.
- A lack of communication regarding quality exists.
- Most of the communication among these organizations is directed toward issues regarding service and the quality of the service.
- Customers have no formal mechanism to communicate product quality concerns,

Figure 2 Actual life safety system supply chain



Supply Chain Management: An International Journal
Volume 9 · Number 4 · 2004 · 323-330

requirements, improvements or suggestions regarding the life safety systems.
- Relationship is shown as a faint, unidirectional arrow from the end customer to the distributor in Figure 2.

Distributor-manufacturer
- Information from the end-customer is not communicated to the manufacturer and, therefore, customer concerns are not addressed.
- Communication between the manufacturer and the branches of the distributor exists only through branch personnel and the customer service and technical support groups at the manufacturer.
- Communication between the distributor and the manufacturer is extremely one-sided, with the manufacturer having the stronger influence.
- Quality communication is essentially non-existent at this level in the supply chain.
- Relationship is shown as a thin, unidirectional arrow from the manufacturer to the distributor in Figure 2.

Manufacturer-supplier
- Communication between the manufacturer and the supplier is open and multi-directional.
- Formal mechanisms exist to communicate problems and feedback to each other.
- Quality communications exist mainly through the corrective action system, although formal quality goals are not communicated to the supplier.
- Relationship is shown as a solid, two-directional arrow with the stronger arrow pointing from the manufacturer to the supplier in Figure 2.

Supplier-sub-supplier

- Simplistic product being produced at this stage.
- Relationship based simply on product for cash exchanges.
- Communication is open and encouraged, although most occurs through product specifications and drawings.
- Sub-supplier is directed (receives product and quality information) from the supplier.
- Quality is not specifically addressed, although the communication is adequate given the simplistic product.
- Relationship is shown as a thin unidirectional arrow from the supplier to the sub-supplier in Figure 2.

The analysis demonstrates the inconsistencies that exist within the chain. The end customer was not the focus of this supply chain. In fact, the consumer, or end customer, had little influence on the chain other than purchasing the life safety systems. The dominant influence in the chain rests with the manufacturer, who is responsible for manufacturing the system as well as converting vague corporate goals into specific quality objectives. It is their goals and production that set the pace for the rest of the supply chain, although they have no direct customer contact. Even though this influence was dominant, goals were not adequately communicated to the bottom level (sub-supplier) in the chain.

Quality goals and objectives were communicated and interpreted differently at the different levels in the supply chain. At the distributor level, the distributor imposes its own goals of customer satisfaction and system functionality on themselves internally. Even though they have direct contact with the customer, they are unable to determine customer goals and pass them on to the supply chain. The distributor does not pass on their goals to the lower entities within the chain, nor do they receive any imposed quality restrictions or guidelines from the other entities. Rarely does the distributor provide any feedback to the manufacturer. It is at the manufacturing level where the majority of quality goals and expectations originate. The manufacturer attempts to meet their own quality objectives internally, although they do have several formal communication mechanisms with their suppliers such as a corrective action system and supplier approval process. The next level in the supply chain, i.e. the supplier, has adapted these mechanisms into its organization. This level shows the dominant influence of the manufacturer and its quality programs as they begin to move down the supply chain. The manufacturing influence and formal communication stops at the supplier level. The sub-supplier has a documented quality system and communicates with its customers on a need-only basis. Quality communication occurs only through product specifications and drawings.

Most of the entities within the chain, although concerned with customer satisfaction, did not adopt the same quality goals and standards. Quality goals, specifications and restrictions were extremely dissimilar at different levels within the chain. The distributor focused on end-customer satisfaction through service, while the manufacturer focused purely on product quality with little regard for customer expectations. The supplier focused on producing a quality product, but was more concerned with the requirements imposed on them by the manufacturer. The sub-supplier concentrated solely on manufacturing the product per print.

Supply Chain Management: An International Journal
Volume 9 · Number 4 · 2004 · 323-330

The different levels in the supply chain also had separate standards through which to qualify their direct suppliers. The distributor was unconcerned with this issue, since they receive all of the systems they sell and service from the manufacturer, who controls the relationship. The manufacturer, however, had extremely rigid standards for supplier approval as well as a continual quality evaluation process that includes a report card and corrective action system. The supplier also has a supplier approval process, but does not have any type of program to continually evaluate its suppliers at this time. No certifications are required for the sub-supplier.

The issue of partnerships seemed to stir up a varied set of reactions with one overall conclusion: true partnerships do not exist within this supply chain. All entities considered themselves to have open working relationships with their suppliers and customers, but no partnerships exist. The relationship that most closely resembled a partnership is between the manufacturer and the supplier. The supplier did consider the manufacturer to be a business partner. However, the manufacturer did not consider the supplier or any of its suppliers to be partners. Although the relationship does have some characteristics of a partnership, the manufacturer appears to be hesitant to commit to future business or a sole-supplier relationship. As the Director of Business Development at the supplier states, "The only thing our relationship is lacking is the vision of where we're going together in the future" (supplier transcript, 2001). With the manufacturer being the dominant influential organization within the supply chain, and being unable to commit to a partnership relationship with its suppliers, it is unlikely that the other entities within the chain will view their suppliers or customers as business partners.

To conclude from this analysis that this supply chain is inept or dysfunctional would be incorrect. The supply chain is very successful with the life safety systems. The end customer is serviced successfully even though the entities in this connected supply chain are not closely linked and have dissimilar quality goals. Perhaps this supply chain has the minimum level of quality communication and goal alignment necessary to exist within their relatively mature and stable product market. However, it appears as though the main reason for the success of the supply chain, despite several weak connections or relationships, is the strength or dominance of the manufacturer. Strong and frequent unidirectional communication exists between the manufacturer and the supplier and between the manufacturer and the distributor. These connections appear to be the crux of the supply chain. It is from this strong relationship that the supply chain is able to remain successful while communication weakens and disappears at either end of the supply chain.

References

Birch, D. (2001), "Room for improvement", *Supply Management*, pp. 34-5.

Cooper, R. and Yoshikawa, T. (1994), "Inter-organizational cost management systems: the case of the Tokyo-Yokohama-Kamakura supply chain", *International Journal of Production Economics*, Vol. 37, pp. 51-62.

Mangiameli, P.M. and Roethlein, C.J. (2001), "An examination of quality performance at different levels in a connected supply chain: a preliminary study", *Integrated Manufacturing Systems: The International Journal of Manufacturing Technology Management*, Vol. 12 No. 2, pp. 126-33.

Narasimhan, R. and Jayaram, J. (1998), "Causal linkages in supply chain management: an exploratory study of North American manufacturing firms", *Decision Sciences*, Vol. 29 No. 3, Summer, pp. 579-605.

Purchasing (1990), "Tracking quality through the supply chain", *Purchasing*, Vol. 108 No. 1, pp. 99-103.

Roethlein, C.J., Mangiameli, P.M. and Ebrahimpour, M. (2002), "Quality in US manufacturing industries: an empirical study", *Quality Management Journal*, Vol. 9 No. 3, pp. 48-66.

Ross, D.F. (1998), *Competing through Supply Chain Management: Creating Market-Winning Strategies through Supply Chain Partnerships*, Chapman & Hall, London.

Wisner, J.D. and Tan, K.C. (2000), "Supply chain management and its impact on purchasing", *Journal of Supply Chain Management*, Vol. 36 No. 4, Fall, pp. 33-42.