

Using Interorganizational Information Systems to Support Environmental Management Efforts at ASG

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Keywords

integrated chain management (ICM)
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Summary

We examine use of environmental information systems by ASG AB (hereafter ASG), an international logistics and transport firm headquartered in Stockholm, Sweden, as a case study to illustrate the role of information systems in life-cycle-oriented environmental management. This case provides an example of how a firm can use interorganizational information systems (IOISs) to move toward environmentally sustainable business practices. Through the use of IOISs, ASG has been able to improve its environmental performance and that of its suppliers. Further, this improved environmental performance has been a competitive advantage for ASG and enabled it to attract new business. As such, ASG's experiences illustrate how aggressive practices move environmental management beyond compliance and cost control, at which many firms have been successful, to revenue generation. The case also shows how environmentally sustainable business practices can be integrated into a firm's strategy. In addition to illustrating how ASG has used IOISs to improve environmental performance, we compare their use of environmental ISs with the expected evolution of environmental ISs presented in the Shaft and colleagues (1997) framework. Although some of ASG's experiences verify the expected progression of these types of systems, some developments are not as expected. These differences have implications for the framework.

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Introduction

Shaft and colleagues (1997) posited a framework for the development of information systems (ISs) to support life-cycle-oriented environmental management, or life-cycle management (LCM).¹ At the time that the framework was developed, working examples of the capabilities of different types of environmental ISs were unavailable. Instead, the types of ISs to support LCM were defined in terms of environmentally oriented systems plus the nature of the extensions that would be needed to enable such systems to support LCM. At this time, we extend the work presented in the earlier framework via a case study of the use of ISs by ASG AB (hereafter ASG) to support its environmental management practices. We selected ASG because of its use of ISs to support the flow of environmental information between firms and its development of specific software tools to enable this flow of information. In many respects, ISs to support LCM are still in their infancy, at ASG as well as other firms; however, our findings from this case study can provide guidance to other firms that wish to adopt LCM. Further, the findings support portions of the initial framework but indicate that other elements of the framework may benefit from revision.

Previous Research

As early as 1992, Bagnall (1992, 9) noted that “[m]any customers, clients and customer organizations are starting to demand information about environmental policies and performance, to seek assurance about management systems and controls and to require comprehensive environmental data relating to products and services.” Because environmental information is not found in typical accounting or production ISs (Steger 1996), new information flows and information subsystems must be developed to support environmental management (Graedel and Allenby 1995).

Early ISs to support environmental management needs focused on compliance and typically possessed monitoring and reporting capabilities (cf. Hennessy 1993; Martin 1993). Although

such capabilities could be considered limited when contrasted to the scope of possibilities, these systems can yield significant benefits. Delta Airlines replaced their manual environmental reporting system with a commercial software package and reduced the number of man-hours required for reporting purposes by half while improving the accuracy of the reports and reducing the usage of monitored chemicals (Balzer et al. 1997). These benefits were achieved despite the fact that Delta’s system does not integrate with other systems, nor does it support interfirm environmental management efforts. Commercially available environmental management software packages have evolved to the point where most include modules for hazardous materials inventory, emissions reporting, and compliance activity documentation (Murray et al. 2000).

The continued evolution of ISs to support environmental management is evidenced by the Modular Energy System Analysis and Planning software, which provides decision-making support for energy and environmental planning tasks by linking a database of cases with planning modules that include simulation and financial analysis (Schlenzig 1999). The shift away from monitoring and reporting to decision support to assist environmental management efforts is consistent with the need to integrate environmental management into general management practices as “[s]ound energy and environmental accounting must be the basis of any strategic decision making in order to keep up with the increasing complexity of energy and environmental problems” (Schlenzig 1999, 81). Commercial environmental management packages have evolved similarly, and some include capabilities such as facilities management, compliance auditing, or geographic ISs (Murray et al. 2000).

Despite the benefits of environmental management ISs, the challenges of creating these ISs have been noted for some time. Environmental management ISs cannot function effectively unless other reporting and accountability structures are in place (Martin 1993). Further, “environmental data are found throughout the plant, in different formats, on different systems, using different databases, resulting in little or no integration to make informed and timely decisions”

(Nielsen 1993, 1870). Nielsen raises the issue of information gaps in the context of systems within firms. The interorganizational gaps are probably more challenging, however. "Information infrastructure gaps also arise when information needs cross organizational boundaries, creating too many drivers going in different directions without paying attention to each other"; further, "[a]n effective information infrastructure often needs to penetrate organizational boundaries, even when no single entity exists with the authority to control all the organizations" (Metzenbaum 2000, 28).

The need to consider "cradle-to-grave" issues consistent with LCM implies the requirement to measure and track resource consumption plus waste and emissions until a product is consumed or used by its owner (Murray et al. 2000). These requirements are expected to foster environmental e-business to facilitate the collection of interfirm information (Murray et al. 2000).

A few researchers have been thinking about the ways interfirm information will be handled in LCM. Recent work by Krikke et al. (in press) does an excellent job of summarizing the variety of specialized ways in which information technology tools have been (or are being) designed to support one particular area of LCM: closed loop supply chains (CLSCs). The authors described the critical areas in which these tools are needed as follows:

Critical IT areas in CLSC are MRP [materials requirements planning] for recovery, electronic marketplaces for returns, reverse logistics (warehouse management) systems and product eco-tools. Specialized tools with impressive functionalities have been developed and their use is widespread in business practices. (Krikke et al. in press, 26)

A related, small body of literature has begun to develop that examines information issues in the reverse logistics portion of LCM as well (e.g., Daugherty et al. 2002). Building on previous work on information issues in logistics in general (e.g., Closs et al. 1997; Daugherty et al. 1995; Mentzer and Firman 1994; Rogers et al. 1991; Stank et al. 1996) and consistent with the ar-

guments we present below, Daugherty and colleagues (2002; 87) suggested that "[i]nformation support is particularly critical to achieving efficient reverse logistics operations. Reverse logistics is frequently characterized by uncertainty and a need for rapid timing/processing."

With the exception of the specialized tools described by Krikke and colleagues (in press), the remainder of the ISs we describe above lack the ability to cross organizational boundaries. Further, not even the interorganizational tools Krikke and colleagues (in press) or Daugherty and colleagues (2002) described provide comprehensive IS solutions for firms using LCM. Rather, these tools address specific (albeit important) elements of CLSCs. Note, however, that ASG, the focus of this study, has already achieved some measure of the systemic capabilities described by Murray and colleagues (2000) as the future of environmental ISs. ASG has developed ISs to collect information from their suppliers, which they use in turn to provide detailed information to their customers. ASG's use of ISs to support interfirm environmental management efforts is relatively unusual and provides an opportunity to better understand the role of ISs in LCM.

In following sections, we employ a framework of LCM ISs (Shaft et al. 1997) to structure our description of ASG's environmentally oriented ISs. In our research we were unable to identify other models of ISs specifically to support interfirm environmental management or interfirm ISs in general. The framework proposed by Shaft and colleagues (1997) describes the types of and interrelationships between ISs that are expected to evolve to support LCM, thus providing a structure for our observations.

Methodology

The primary source of the information presented in this case was a series of interviews with Magnus Swahn, then of ASG. Mr. Swahn was our point of contact for several reasons. First, at the time of the initial interview he was the only person at ASG headquarters who handled environmental management issues. Further, as a direct reporter to the chief executive officer (CEO), he was able to provide the details about

ASG's environmental management efforts, as well as insight into how these efforts were incorporated into ASG's strategy and overall business. Finally, Mr. Swahn speaks fluent English, which enhanced and simplified communication.

We conducted three formal interviews, the first in July 1997 in Stockholm, Sweden. At that time, we were engaged in a larger study for which we performed interviews at several Scandinavian companies. From this larger study, it became apparent that ASG's use of ISs to support environmental management efforts with customers and suppliers was unique. To gain a better understanding of these efforts, we conducted two additional interviews via phone (January 1998 and April 2001). These interviews focused on ASG's use of ISs to support environmental management efforts involving customers or suppliers. The first two authors (Shaft and Sharfman) conducted all interviews jointly. We had all interviews transcribed and used e-mail to clarify and elaborate details where necessary. Further, Mr. Swahn examined the contents of the article to verify that the information was correct and accurate.

In addition to the material provided by Mr. Swahn, we reviewed internal ASG proprietary documents as well as public material available on the ASG and Danzas Web sites (see below for a discussion of the relationship between ASG and Danzas). In addition we reviewed a commentary on ASG's environmental activities, including their IS efforts (see Friend 1997).

Description of ASG

In this section we describe ASG, its business strategy, and its general environmental stance. At the time of the case study, ASG was a multi-divisional company that operated in several major business segments in the logistics and transportation industry. The firm was headquartered in Stockholm, Sweden, and had operations primarily in the Nordic and Baltic regions. In addition, the firm had a U.S. subsidiary and was developing operations in several Asian countries. The firm organized itself into four major business areas:

- European road transport (international road transportation) and local package delivery (domestic transport in Sweden and Norway and transport of parcels)
- Air and sea (air- and sea-borne transportation)
- Specialist companies (niche operations including truck haulage, furniture transport, clothing transport, and heavy/project transport)

According to the 1998 ASG annual report (Danzas 1999), the firm had net sales of SKr 11,965,000,000 (approximately US\$1,144,000,000 or €1,292,720,000), with profits of SKr 1,123,000,000 (approximately US\$128,750,000 or €145,487,500). These figures represent SKr 8.06 per share (approximately US\$1.74) and a 5.6% return on equity. More recent financial figures are difficult to obtain because the Danzas Group, a Swiss-based multinational logistics provider, acquired ASG in August of 1999. Deutsche Post World Net (a German conglomerate in the shipping, mail, and logistics fields) in turn acquired the Danzas Group in February 2000.

Prior to the takeover, ASG had been transformed from a delivery company to a more integrated logistics firm. For the reader unfamiliar with this business, logistics service providers manage all or part of a firm's supply and customer chains. In the supplier chain, logistics providers offer transport and shipment management services that may include, for example, delivery, warehousing, or "just-in-time" delivery. On the customer side, they offer delivery services as well but also may manage/store inventory and handle order fulfillment. In Europe increasingly they offer "reverse logistics," that is product, packaging, and shipping container take-back services. Jörger Ekberg, president and chief executive officer at the time, suggested:

The demand for integrated solutions and logistics efficiency is shifting demand for transport services towards ready-made solutions, meaning effective networks for the production of transport services, as well as customized total structures. Concurrently, customer procurement of transport and logistics services is becoming increasingly sophisticated. Other market

trends affecting developments in the industry are . . . increasing environmental awareness among customers. (ASG 1998)

Friend (1997) argued that the transition from a transportation company to a logistics firm brings with it a different view of the role of the environment. The new view is summarized in the firm's environmental policy statement at that time (ASG 1998):

ASG strives for the development of sustainable transport and logistics systems. We shall prevent and minimize our negative environmental impact by:

- Continuously improving our performance regarding the environment and safety in a businesslike way
- Preventing incidents and accidents that have a negative impact on health, the environment, and materials
- Complying with laws and other requirements, and assuming social and ethical responsibility
- Communicating and cooperating with all stakeholders and openly reporting on performance and new developments

Like all firms, ASG faces national regulatory requirements, so it has instituted programs to meet these obligations. In addition, many local communities have also adopted specific environmental initiatives. In Sweden specifically, Agenda 21² efforts have targeted the transport sector. ASG has developed a specific program for itself, its contracted haulage companies, and its customers to respond to Agenda 21 programs (ASG 1996).

ASG also sees itself addressing global environmental trends. In the most direct method of doing so, the company obtained overall certification for its environmental management system under the global ISO 14001 environmental quality management standards by the time this case was written.

Finally, like all firms, ASG is under increasing pressure to manage its environmental footprint more extensively—beyond their own boundaries, to include the entire physical system life cycle of their products or services (i.e., the value

chain; cf. Porter 1985; Sharfman et al. 1997, 1998). This broader perspective entails an examination of environmental effects from the creation of inputs to the final disposal, decontamination, recycling, or reuse of outputs. The incentives for firms to adopt this LCM-oriented approach come from such disparate sources as the Dutch regulations concerning life-cycle assessment (a technique for analyzing the environmental effect of a product or service through its life cycle; cf. MHSPE 1994), U.S. government regulations on chlorofluorocarbon labeling of supplied products, European Union product and packaging take-back initiatives such as the German Duales System Deutschland and the Swedish Kretslopp programs, and the provisions of ISO 14041 (the life-cycle assessment, inventory, and evaluation portion of the international standards for environmental quality). Further, leading-edge firms such as AT&T, DuPont, Interface, Inc., and Storebrand are raising the standard for others in their industries by using life-cycle approaches for competitive advantage.

The LCM approach allows firms to improve environmental quality by fully examining the entire life cycle of products/processes to identify more environmentally benign methods and materials: however, a firm could appear to improve environmental quality by simply selecting inputs that force any negative environmental impact upstream to a supplier or by moving finishing steps outside the firm. One of the key reasons that the U.S. "Superfund" legislation (Comprehensive Environmental Response, Compensation, and Liability Act [U.S. Congress 1980]) was passed was to require firms to take financial responsibility for hazardous waste disposal that they had inappropriately or perhaps illegally passed on to waste haulers (suppliers). These suppliers often disposed of the wastes by any means they could, sometimes with little concern for the environmental impact. Waste generators have tried often to distance themselves from this liability, but the U.S. courts routinely have denied such claims. As such, segments of the logistics/transportation industries have a rather inglorious history of ignoring life-cycle issues. Recent examples of environmentally unsound and even illegal dumping by waste haulers range from the infamous environmental disaster caused by

illegal/careless spreading of dioxin tainted waste by a hauler in the Times Beach area in Missouri in 1971 (see the account by the U.S. EPA (1998) for details) up through recent, international illegal toxic-waste dumping (e.g., the transport ship the *Khian Sea* illegally dumping waste on a Haitian beach; see Greenpeace 1992). For a firm truly to improve environmental quality, it must consider the effects both up- and downstream from its own efforts. To address these life-cycle effects, the environmental activities of suppliers and the environmental needs of customers must become part of environmental quality management efforts. As a logistics supplier, the shift to a life-cycle view places ASG in the center of this effort.

Inherent in managing from the life-cycle perspective is the need for extensive amounts of new information processing (Murray et al. 2000). ISs will play an increasingly important role in corporate environmental management by "completing a necessary feedback loop for environmentally appropriate behavior by corporations" (Graedel and Allenby 1995, 90). This is especially true for LCM because it is particularly information intensive, requiring detailed information on pollutants, emissions, resource usage, material characteristics, production alternatives, government regulations, and new technologies. The information for LCM will come from within the focal firm as well as from suppliers, customers, and external data banks. By "focal firm," we mean the firm that defines the value chain or life cycle (i.e., the firm that defines who is a customer and who is a supplier). Any firm can be the focal firm; it is a matter of perspective. Internal and interorganizational ISs will be necessary to process the information required to establish and maintain LCM. In this article, we describe how ASG is using LCM ISs to further its operational and strategic goals (cf. El Sawy et al. 1999).

ASG and LCM

Before we describe how ASG is using LCM ISs, we briefly describe how ASG has implemented LCM. Essentially, the transition to a logistics orientation required that ASG look beyond its boundaries to its suppliers and customers. On the supply side, ASG has two

types of suppliers. Like all firms, it buys a wide variety of products, from fuel to vehicles to paper clips. ASG addresses the environmental performance of these suppliers through preferential purchasing from suppliers of more environmental friendly products and services. Although there is a wide degree of variation in the ways that the various business units monitor the environmental performance of suppliers, there is an increasing trend toward it as the firm further integrates environmental issues into its strategy.

The most environmentally important suppliers for ASG are the haulage companies. Although approximately 4,000 vehicles sport the ASG logo, ASG owns only about 5% of the fleet. The rest of the vehicles that operate under ASG's logo are contracted. ASG can tout the environmental performance of only its own fleet; however, it considers the environmental performance of its haulage suppliers' vehicles as its own and monitors their performance as closely as that of its own fleet.

As for the customer side of the value chain, ASG sees itself in partnership with the companies that purchase its services. This partnership manifests itself environmentally in two ways. First, ASG works with its customers to design the most environmentally efficient transport and logistics programs it can offer at a competitive price. Second, as ASG's customers face mounting pressure for improved environmental performance, they pass the requirements to ASG. ASG is then in position to build partnerships with its customers to find environmental solutions.

The benefits ASG reaped from these practices were threefold. First, ASG retained customers, even as customers increased environmental performance standards. For instance, Baxter, a multinational producer of healthcare supplies and equipment, created a set of environmental criteria for its suppliers, and if ASG had not achieved a 65% rating, ASG would have been dropped. After achieving an 80% rating, ASG aimed higher and achieved 100%, the only third-party supplier worldwide to do so. The interaction with Baxter is interesting because ASG had exceeded Baxter's requirements by achieving 80%, thereby surpassing Baxter's requirements by 15%. Yet when ASG pursued recertification by Baxter, their objective and achievement was a

score of 100%. Although there is no direct economic advantage to exceeding the standard, ASG believes that by achieving 100%, and being the only supplier worldwide to do so, they significantly tightened their relationship with Baxter.

Second, ASG was able to increase the level of services offered to customers because of their environmental management expertise. By handling take-back needs, ASG was able to solve one of Kodak's major problems. Although take-back is a standard logistics problem, because of the nature of developing films and fluids there was a critical environmental component to the problem. ASG took back the hazardous material and extracted the silver from the wastes, allowing ASG to minimize environmental impact as a result of good logistics practices (i.e., minimizing transportation) and handling the hazardous waste simultaneously. Kodak's increased reliance on ASG meant that Kodak faces higher switching costs. That is, switching from ASG to another haulage firm would require also finding a firm or firms that could provide the take-back and hazardous-waste management services as well.

Finally, and perhaps more importantly, ASG was able to use their environmental performance to gain new customers. Securing new business from Dow Chemical was the most notable example of their ability to gain new customers.

Part of ASG's ability to address the environmental needs of its customers is the result of the ISs we describe below. Through them, ASG can make verifiable claims about its environmental performance. These systems in turn give ASG's customers more accurate information about additional segments of the life-cycle effects of their own processes.

ASG's Commitment to the Application of Information Technology

Before we describe ASG's environmental ISs, we present the following material, which shows the extent to which ASG was already committed to both internal and interorganizational information technology:

Information technology (IT) is a crucial tool, not only for ensuring cost-effective

production, but also for offering customers added value in transport services. In IT services, customers will be offered ready-made and customized solutions that offer them added value. (ASG 1998)

The services provided to customers include electronic data interchange for booking transport, transfer of waybill information, confirmation of goods, and invoicing, which offer major efficiency benefits for both the customer and ASG. ASG's customers, through the Internet and other links, have electronic data access to information from ASG's various production systems. Further, ASG relies on IT solutions to achieve paperless production in goods processing and administration. Mobile data communications, digital waybills, scanning of labels, and documents are a few examples.

We should note that ASG developed the system we describe below in an evolutionary way rather than through intentional planning. Three key elements defined this evolution. First, the systems grew as ASG's own IT sophistication developed. The extranet we describe below that haulers use was developed to provide a "track-and-trace system" for customers, among other things. The environmental components were added later. Second, increases in the sophistication of both what ASG and its customers needed dictated increases in the sophistication other ISs ASG had to implement with its haulers. Third, the firm's IT and corporate strategies coadapted with each other (cf. El Sawy et al. 1999) so the firm developed LCM ISs to be consistent with its LCM strategy.

ISs to Support LCM at ASG

We organize our discussion of ASG's ISs to support environmental management around the framework developed by Shaft and colleagues (1997). The framework was developed from existing models of ISs and expanded to include the types of capabilities needed to support the interorganizational needs inherent in LCM. Following our description of the different types of systems, we discuss the nature of their interrelationships.

Descriptions of Types of ISs

The framework includes five common types of ISs (office automation, transaction processing, management information, decision support, and executive information).³ For each type of IS, we first include a summary description of the type of IS based on the original framework by Shaft and colleagues (1997), and readers are referred to it for a more detailed discussion of the general types of ISs. Following the summary description of the type of IS, we describe ASG's efforts in that area.

Office Automation Systems

Office automation systems (OASs), sometimes known as office information systems, support information workers (including professional staff and clerical workers). In LCM, the communication role of OASs plays a vital function supporting intra- and interorganizational communications. Because the volume of communication that an LCM approach entails would swamp traditional "paper-and-pencil" systems, OASs will be integral to the success of LCM. Given the informal nature of an OAS's outputs, it is unlikely that specific LCM OASs will exist. Instead, the role of current OASs will expand to support the flow of interorganizational information between member firms.

OASs for Environmental Support at ASG

Consistent with the arguments presented by Shaft and colleagues (1997), there are no unique OASs to support environmental initiatives at ASG; however, existing OASs have been integral to supporting communication between ASG and suppliers. Currently, some systems are supported by ASG's extranet. An extranet is an Internet-based system that provides access only to those with permission, such as suppliers and customers. In 1998, only a few suppliers used e-mail to communicate environmental data to ASG. Instead the majority submitted the information on disks via surface mail. The evolution from surface mail to use of an extranet to exchange data allows for more complex interchanges. As we note in the sections on transaction processing systems and management information systems (below), ASG now offers more sophisticated environmental information

to customers, in part enabled by the existence of the extranet.

Transaction Processing Systems

Transaction processing systems (TPSs), also known as data-processing systems, support the day-to-day information processing of an organization. TPSs process the most detailed data in a firm, supporting the basic business functions of an organization, that is, both internal and external transactions. Within LCM, TPSs gather data on resource utilization as well as gaseous, liquid, and solid emissions from the focal firm. These data are used for internal management and planning plus external compliance reporting. TPSs may also monitor resource uses and emissions from members of the value chain. TPSs provide the ability to integrate data from members of the value chain into the focal firm's TPS to provide a complete picture of the value chain's effect on the environment.

TPSs for Environmental Support at ASG

Historically, TPSs were developed first within organizations, and Shaft and colleagues (1997) predicted that LCM efforts would require the early development of linkages between member firms' TPSs to support the exchange and processing of environmental data. We find, however, that LCM ISs did not evolve in that fashion at ASG.

In 1998, much interfirm environmental information was supported by informal OASs (which support more informal than formal, i.e., fixed format, types of data communication) and also by surface mail. Interestingly, this occurred because, given the vast amount of data that needed to be communicated, developing an IS to support the transmission of environmental data exclusively would have been quite costly. Therefore, suppliers and customers were provided with environmental declarations on an aggregate basis. Suppliers and customers could monitor ASG's environmental performance at the fleet level. On a few occasions, however, customers requested environmental declarations at the shipment level, that is, the environmental impact of a particular shipment. In these situations, the declarations had to be prepared by hand. Such manual preparation was costly and difficult,

so ASG did not market this capability; but demand for that type of specific environmental information increased to the point that by 2000 ASG developed an on-line capability for customers to access this information. As part of ASG Access, which was provided via an extranet, over 2,000 customers have access to a variety of services including a track-and-trace system and the ability to monitor the environmental performance of their domestic shipments, enabling them to determine the environmental impact of their shipments. The system tracks a variety of environmental indicators focused on energy and emissions such as levels of nitrogen oxide, carbon dioxide, and hydrocarbons. Note that shipment-level computations are based on fleetwide standard energy and emission figures and specific to the customer's shipments. Because this information is provided via the extranet, customers access this information on demand.

The ability to provide shipment-level environmental performance data came relatively late and is not based on a linkage to ASG's suppliers' TPSs (the linkage is described in the section "Interrelationships among the Types of ISs"). The late development of TPSs to support environmental management is inconsistent with what was envisioned for LCM ISs. Further, Shaft and colleagues (1997) argued that interfirm communication between focal and nonfocal firms' TPSs would be one of the first two links established, the other link being that between OASs. A TPS to TPS link has not been established, however. We discuss this issue more fully after we conclude our discussion of the other types of systems.

Management Information Systems

Management information systems (MISs) support the general information needs of managers, with a focus on providing the information to support the control function in an organization. MISs typically provide managers with regular and routine reports to monitor the status of an organization via periodic reports or exception reports. Because MISs are reporting and control oriented, they focus more on providing the information to identify potential problems and less on solving those problems. MISs will be essential to LCM to support required monitoring and control. Within a focal firm, the MISs help monitor

performance. With other members of the value chain, the information from the MISs can be used in advisory ways to assist in problem identification and performance monitoring. Unless contractual relationships develop, the interorganizational monitoring role of the MISs will be advisory. As the focal firm will be likely to have the most developed monitoring tools, however, its MIS could provide valuable information to other member firms.

MISs for Environmental Support at ASG

ASG's system for obtaining environmental management information is one of the most sophisticated of their environmentally oriented systems. Suppliers, via ASG's extranet, provide ASG with details of their fleet's environmental information. This information includes items such as type of vehicle, type of engine, fuel consumption, onboard IT system (e.g., mobile data computer), fuel-saving devices, low-friction tires, and tires that do not emit hydrocarbons. This information is evaluated through ASG's "environmental scoring system." This scoring system is broken down such that 35 points relate to management activities to improve environmental performance of the hauler (for instance, whether the hauler has an environmental management system), and the other 65 points are based on technical issues (for instance, fuel consumption). Starting in 1999, haulers were required to achieve a certain score to remain an ASG contractor. At the time of this writing, however, no hauler had been dropped because of environmental performance. Haulers knew the details of the evaluation system, and each could determine the means by which they achieve the required score. For instance, a firm that is planning to replace its current vehicles may choose to purchase vehicles with highly efficient engines, whereas another firm with newer trucks could find it more efficient to purchase low-friction tires or to focus on managerial issues.

ASG assembles the information from all the road haulers, which can then be provided to ASG's customers. Initially, haulers provided this information to ASG on an annual basis, but it is now provided biannually. Currently, the system is only used to assess haulers. ASG has focused on road haulers because they constitute the larg-

est number of suppliers and are believed to create the greatest environmental impact. Proprietary ASG data suggest that the haulers view the system positively. Additional proprietary data indicate the environmental impact of the system—that most, if not all, firms improved their environmental performance. Better-performing firms improved environmental performance more quickly than the lower-performing firms, however, widening the gap between the best and worst.

As we mentioned previously, we anticipated that interorganizational links between TPSs would precede the development of linkages between MISs. Hence, finding that ASG's most elaborate IOIS for environmental support exists in an MIS was surprising. We discuss this finding more completely in the discussion section.

Decision Support Systems

Decision support systems (DSSs) support the problem-solving needs of individual or small groups of managers engaged in analytical decision making for the firm. DSSs are typically narrowly focused and, therefore, produce specialized reports on an "as-needed" basis. A problem-solving session with a DSS is typically user initiated and interactive (as opposed to time- or exception-based processing). Because of the specialized nature of DSSs, capabilities vary greatly from system to system. DSSs are important to LCM to support the numerous decisions (e.g., choices among production processes, or inputs) requiring the consideration of numerous variables, including environmental impact criteria. In LCM, valuable support is expected to come in the form of quantitative models to analyze the environmental impact of the total value chain. Quantitative models will be useful in determining at what pollutant levels the firm and the value chain should operate. Such decisions consider numerous alternatives and multiple criteria (e.g., improvements with respect to one type of waste may yield inferior results with respect to a different type of waste).

DSSs for Environmental Support at ASG

The majority of current DSS tools for LCM support life-cycle inventories of manufactured

products. As a logistics firm, ASG does not manufacture products, hence the current tools do not support the types of problems relevant to ASG; however, environmental information does affect decision making at ASG. For example, records of all environmental discharge incidents are collected throughout the year to provide a profile as to the sorts of environmental risks to which ASG is exposed. The incident data are accumulated in a database annually, which is the foundation for that section of the firm's environmental report. Based on the incident data, probability analyses are conducted. When necessary, new programs are created to train personnel in proper safety and handling procedures. These improved procedures are in turn likely to limit the firm's risk.

The lack of specific DSSs to support environmental efforts at ASG is somewhat inconsistent with the initial framework, which suggested that "DSS[s] will be important to LCM to support the numerous decisions . . . requiring the consideration of a number of variables, including environmental impact criteria" (Shaft et al. 1997, 141). We believe, however, that this discrepancy is due to the nature of ASG, specifically that much of its business is conducted through a network of contract haulers. As such, many of the decisions regarding changes to reduce environmental impact are made by their suppliers, primarily road haulers. Therefore, there has been less pressure on ASG to create DSSs to support environmental management efforts. It would be interesting, however, to find if this observation holds for similar firms and whether or not manufacturing-oriented firms indeed place more emphasis on DSSs.

Executive Information Systems

Executive information systems (EISs) support the information needs of firms' highest-level executives. Characteristics of EISs include providing on-line access to both internal and external information. Two unique qualities of EISs are the ability to "drill down" and the ability to deal with both "hard" and "soft" data. Drilling down enables executives to start at summary data and then move down through multiple data levels to access more detailed underlying information. The focus on both hard and soft data gives ex-

executives access to data from existing databases (hard data) and supports the need to collect and store less formal (soft) data, such as rumors, news, or ideas. Soft data can require special data collection efforts and can be labor intensive to incorporate into an IS. LCM is a strategic choice, sometimes made as a means to gain competitive advantage (Graedel and Allenby 1995). The purpose of EISs within LCM is to provide on-line access to data in an organized, easy-to-use fashion for executives tracking their firm's achievements with respect to environmental issues.

EISs for Environmental Support at ASG

ASG incorporates EIS capabilities in three areas: drill-down through environmental information, external benchmarking, and environmental scanning. ASG's environmental manager can examine internal environmental information on the firm's physical locations and then look down to more specific information, such as how much water a particular location is using or how much energy is expended per ton of shipments. This information is used in conjunction with competitor information as part of external benchmarking that allows ASG to compare itself on particular criteria to the best performer with respect to that criterion. Competitor information and information regarding performance in other industries are gathered by students as part of school projects and are compiled approximately every three years. Environmental scanning is conducted via annual customer surveys. Currently

these results are not part of an IS, but they comprise an important part of the environmental function at ASG.

Interrelationships among the Types of ISs

Shaft and colleagues (1997) developed a view of the anticipated interrelationships between the five types of ISs in LCM. Their model is based on the interrelationships among systems within a firm (i.e., without LCM) adapted from Laudon and Laudon's (1994) work, as we depict in figure 1. Typically, TPSs are responsible for gathering data about basic transactions; therefore, they do not receive input from the other types of ISs but generate information for the other ISs for problem solving, reporting, and communication functions. OASs, because of their flexible nature, receive input from each of the other types of systems. The OASs can output information to DSSs. MISs receive input from TPSs, mainly in the form of detailed data concerning transactions. The information generated by the MISs can be output to EISs, DSSs, and OASs. DSSs receive input from OASs, MISs, and TPSs. The DSSs output information to the EISs and OASs. EISs receive input from MISs and DSSs.⁴ EISs output information to OASs for communication and dissemination.

When a firm adopts an LCM approach, the relationships among the different types of ISs become more complex because of the interorganizational relationships that must be supported (Shaft et al. 1997). The interorganizational IS

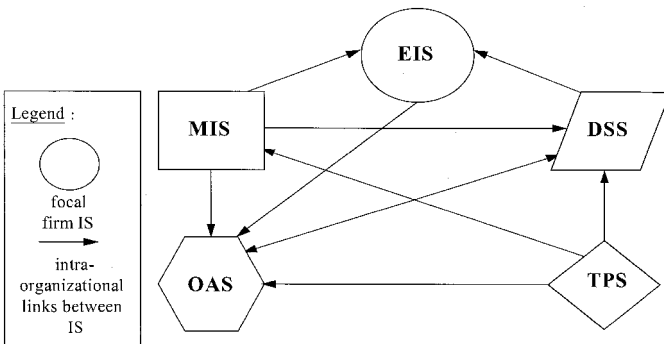


Figure 1 The interrelationships between the five basic types of ISs.

links are expected to evolve from an initial small set, the loosely coupled interorganizational relationships depicted in figure 2⁵ (Shaft et al. 1997). For simplicity, the ISs for each nonfocal firm are not presented; rather, they are represented in aggregate.

In the loosely coupled configuration, two links were considered essential: those between firms' OASs and TPSs. Through the linkage of the OASs, the focal firm and other firms in the value chain are capable of two-way communication. The connection between the OASs is essential because their flexible nature supports informal information. Therefore, this was expected to be the first interorganizational link established (Shaft et al. 1997).

The other interorganizational link depicted is that between the TPSs of the focal firm and the TPSs of the other members of the value chain (Shaft et al. 1997). This link can be supported by a one-way relationship (from members to the focal firm). As such, the focal firm bears the brunt of the information processing in this loosely coupled configuration.

ASG's practices support some portions of the Shaft and colleagues (1997) framework presented in figure 2. First, ASG uses OASs, mainly e-mail and its extranet, to communicate with its suppliers, and initially this was the major IS linkage between ASG and its suppliers. For example, in the early stages of incorporating supplier performance in environmental reporting, suppliers provided environmental information to ASG via diskettes or paper forms that ASG input. How-

ever, suppliers now provide their environmental information directly to ASG's MIS through an extranet. The haulers create information as required by ASG and provide it to ASG, via the extranet, in aggregate form. Such aggregate information is more consistent with that supported by an MIS than a TPS.

This linkage is interesting for two reasons. First, the anticipated TPS-to-TPS link has not been established. Instead, ASG's haulers' MISs transmit aggregate information. This disconfirms part of the Shaft and colleagues (1997) model, implying that the TPS-to-TPS link in figure 2 perhaps should be replaced with one from MIS to MIS. No current or anticipated linkage exists between the TPSs of ASG and its suppliers. Although a TPS-to-TPS link would provide maximum flexibility for subsequent information processing, there are good reasons to avoid linking TPSs. First, the amount of data that would be exchanged makes it unappealing. Transmitting data is not difficult, but collecting large quantities of data from a large group of suppliers requires an amount of bandwidth that many firms would find difficult to provide and maintain. Further, by gathering the environmental figures as aggregated information, rather than data, the processing burden on ASG (the focal firm) is reduced; however, the use of aggregate information limits the precision of the data that ASG can provide to customers interested in environmental performance. ASG relies on the aggregate information to create standardized values regarding environmental performance along haulage

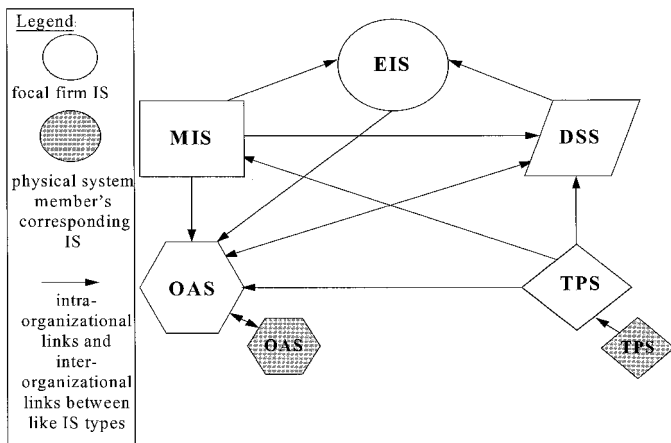


Figure 2 The expected loosely coupled interorganizational configuration.

routes. Customers seem satisfied with environmental information based on the standardized values. Hence, currently there appears to be no incentive to link TPSs to provide more exact information.

The second reason that the linkage between ASG and its suppliers is interesting relates to the way that ASG uses this information within its own systems. As noted previously, the information from suppliers is used to create standard values, which in turn are used to calculate environmental performance along haulage routes. These standard values are combined with ASG's track-and-trace system (which would be classified as a TPS) to provide customers with information regarding the environmental impact of their specific shipments. Through this linkage ASG, in essence, is using the MIS to provide data to the TPS. Such an interrelationship is unusual, as TPSs are typically regarded as sending data to MISs (figure 1). The MIS-to-TPS relationship is the reverse of the standard linkages in which data and information are generally seen as feeding higher-level systems (TPS → MIS → DSS → EIS). Hence, it appears that the interorganizational linkages, such as those necessitated by LCM, have the potential to alter relationships between ISs within a firm as well as necessitate linkages between firms. Based on the interrelationships we discovered among the ISs internal to ASG plus those between ASG and its member firms, we have altered the relationships depicted in figure 2 to create those in figure 3.

Finally, this linkage enables ASG to provide its customers with environmental performance indicators for particular shipments. This information, which previously could be provided to customers only at great cost and inconvenience, is now provided on demand. As early as 1991 (cf. Bakos 1991), researchers have discussed the use of IOISs to leverage unique firm resources, in this case information regarding the environmental performance of haulers, as the mechanism by which firms can use IT to create competitive advantage. The majority of empirical work on IOISs has focused on electronic data interchange, however, because it is perhaps the only class of IOIS extensive enough to support large-sample studies (cf. Hart and Saunders 1998; Angeles et al. 1998, 2000). The potential for IOISs to tighten the relationships of firms in a value chain is widely acknowledged (Rogers and Daugherty 1995; Clark and Stoddard 1996; Chatfield and Yetton 2000); however, ASG provides the only example of the use of environmental information to provide additional value to firms in later steps of the value chain, that is, ASG's customers, of which we are aware.

Discussion

In this section we discuss ASG's experiences with respect to five issues that firms are likely to face when implementing LCM ISs (Shaft et al. 1997): (1) standardization, (2) cost, (3) information exchange, (4) disparities between the goals

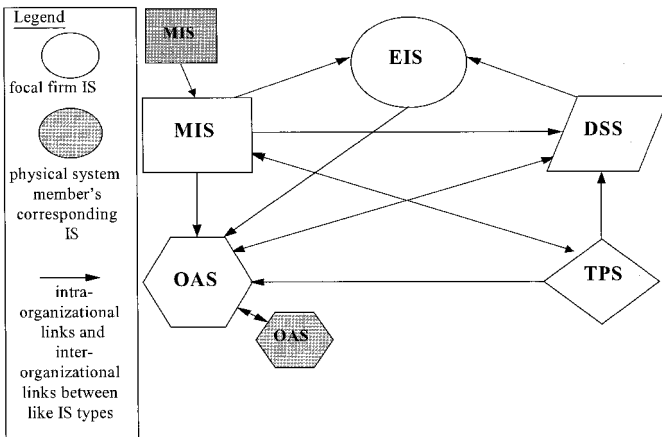


Figure 3 Modified interrelationships between ISs in loosely coupled LCM as identified in the case study.

and objectives of member firms, and (5) power, control, and cooperation between the focal firm and member firms. We also discuss two new issues that emerge from our analysis of ASG: the alignment of environmental management with corporate strategy, and the impact of LCM on the relationships between ISs within a firm.

The issue of standardization revolves around the need for the ISs of the member firms to communicate with that of the focal firm: Questions such as what (whose) standard will be used and how the effort will be distributed across the member firms are key to this issue (Shaft et al. 1997). With respect to ASG's efforts in LCM, the firm developed standards and asked haulers (member firms) to comply. Haulers had limited involvement with the development of communications standards. The migration to the Internet via ASG's extranet for interfirm communication minimizes standardization problems. Specifically, using the Internet to support IOISs removes the need to develop standards for data transmission (Segev et al. 1997). For ASG, the Internet has greatly enhanced connectivity. Only a few years ago, some haulers sent their information to ASG on diskettes via surface mail, rather than via e-mail, an indication of the difficulty of linking firms. Currently, all haulers use the extranet to provide environmental information. Hence, standards to support the transmission of information are less of an issue than anticipated. ASG developed the interface and determined what information to transmit, however; thus, the burden of defining the information to be exchanged seems to fall on the focal firm. It appears that other firms that wish to create LCM ISs should be prepared to define the data and information to be exchanged with member firms.

The second issue raised regards the cost associated with developing IOISs, which are typically expensive (Bakos 1991). In the context of LCM, does the focal firm bear these costs, or should the other value chain members have responsibility (Shaft et al. 1997)? ASG has borne the cost of developing ISs to support LCM at the interfirm level. The haulers bear some costs to provide the environmental information, but none assisted with the cost of developing the ISs. As regulation and customer demands increase the breadth and depth of information that ASG

must report, it will be interesting to see if ASG continues to bear the costs or if they become shared. The ability to use the Internet, as noted above, provides major advantages by reducing the cost of IOISs and enhancing the ability to add new trading partners (Segev et al. 1997). Hence, the ability to use the Internet seems to have minimized problems associated with both the development of data transmission standards and the costs of developing LCM ISs.

Information exchange, rather than data exchange, is the third issue to consider. Little previous research discusses how and when firms transfer information (see Weitz et al. 1994 for a notable exception). While implementing LCM, firms were expected to require extensive external information interchange (Shaft et al. 1997); however, ASG's early exchange of environmental information rather than environmental data was unanticipated. As described above, ASG and its haulers exchange aggregated information rather than transaction-level data. The expectation that interfirm TPS linkages would exist prior to interfirm MIS linkages is based on the historical fact that TPSs developed prior to MISs and that linking at the data level provides the greatest flexibility for subsequent processing. Given the amount and diversity of data that is necessary to understand environmental impact (Allenby 2000; Hennessy 1993; Murray et al. 2000), however, there are good reasons that MIS linkages evolved first. Linking MISs shifts some of the processing burden off ASG and back to its suppliers. Specifically, although ASG must aggregate information (e.g., overall emissions) across firms, ASG does not aggregate the data (e.g., fuel consumption) for a particular firm. This level of information exchange is advantageous to haulers, as certain levels of information remain confidential. It is one thing to provide aggregated information to ASG (who may be regarded as a customer); it is another to allow ASG access to all details. Hence, linking firms' MISs by supporting the flow of information may be a more effective model of LCM ISs than linking TPSs as originally proposed (Shaft et al. 1997). Therefore, we created an alternative framework of LCM ISs that alters the loosely coupled framework presented by Shaft and colleagues (1997) to reflect the interorganizational linking of the

MISs and the intraorganizational flow of information from MISs to TPSs (figure 3).

A fourth issue to consider is that firms along a value chain may have conflicting goals and objectives. Although LCM involves overarching goals that may act as unifying forces for the entire physical system, when the objectives of individual member firms are taken into account, conflicts may arise (Shaft et al. 1997). This potential is clearly illustrated at ASG, where the haulers (who supply environmental information to ASG) wish to maximize their revenue from ASG while ASG wishes to minimize its cost (in turn minimizing revenue to haulers). For environmental reasons, ASG's haulers provide information such as the age of its vehicles, fuel consumption, number of vehicles, and types of engines. This information could be used by ASG to infer accurately haulers' costs, placing the haulers in a poor negotiating position when bidding on routes with ASG. ASG has managed this issue by assuring suppliers that the information will be used *only* for environmental purposes and that the environmental management function will maintain the confidentiality of the information. Our interviews indicate that the other managers at ASG understand the need for this confidentiality and have not undermined it. It should be noted, however, that other managers have their own sources of cost information. Therefore, there was little reason for them to consider the environmental sources for information. Regardless, haulers are unlikely to provide environmental information unless they trust ASG to use the information appropriately. Trust has been raised frequently as an issue for interfirm cooperation in the context of IOISs (Angeles et al. 1998, 2000; Soliman and Youssef 2001; Welty and Becerra-Fernandez 2001). Trust becomes more important as greater diversity of information is exchanged, and there is a positive relationship between supplier commitment and trust (Hart and Saunders 1998). Given the breadth of information needed to monitor environmental performance and ASG's dependence on haulers, the ability to maintain this level of trust seems essential to continued success.

The issue of conflicting goals and objectives is a complex one that firms face as they take on newer organization forms based on a value chain

rather than a formal organizational boundary (Rayport and Sviokla 1995); however, these types of organizational forms can allow firms to offer more to their customers, creating "distinctiveness in customer's minds" (Rogers and Daugherty 1995). Such distinctiveness can be the basis for long-term competitive advantage (Bakos 1991). ASG has chosen to use its and its haulers' environmental performance as a basis for differentiation. Hence, the ability to integrate their haulers into these efforts is essential, and their ability to minimize conflicting goals and objectives between themselves and the haulers, as well as among the haulers, is important.

To minimize conflicting goals and objectives, ASG must accomplish two things. First, it must convince the haulers that high levels of performance for ASG translates into high levels of performance for the haulers, that is, they share a "common destiny" (Angeles and Nath 2000, 243). Second, the haulers must believe that high levels of environmental performance and sharing environmental information contribute to high levels of overall performance. Such shared beliefs help create an overarching goal for members of the value chain, thereby minimizing conflicting goals and objectives. The development of such shared goals appears to be consistent with the IT-supported, interorganizational learning that Scott (2000) described in her research, as well as the idea of interorganizationally "adding value to information" that Soliman and Youssef (2001, 545) discussed.

Two factors have assisted ASG in shaping the environment as an overarching goal. First, the quality of the environment is a cultural issue in the Nordic region. The first United Nations Conference on the Human Environment was held in Stockholm in 1972 (United Nations 2001a), and about 60 Swedish communities have created Agenda 21 programs (Earth Council 2001). Second, energy (i.e., fuel consumption) is a major environmental issue for haulers in the Nordic region. It is also a major cost issue; hence, efforts that reduce environmental impact frequently reduce cost. Note, however, that reductions in fuel costs can be achieved without positive environmental consequences. For instance, disabling emissions control devices reduces fuel consumption (and in turn fuel costs), and the use

of less expensive, higher-sulfur fuels also would reduce fuel costs, with negative environmental consequences. Hence, although many actions haulers take to improve environmental performance may result in reduced fuel consumption, reducing fuel costs and consumption do not necessarily improve environmental performance. Further, if environmental performance were simply a by-product of fuel savings, and therefore strictly an economic issue, ASG would have no reason to establish ISs to monitor environmental performance or to estimate the environmental implications of shipments. Therefore, although the economics of fuel savings make it easier for ASG to turn environmental performance into an overarching goal for itself and its network of road haulers, ASG's choices in managing its system of haulers are also driven by environmental concerns.

The fifth issue is the power, control, and cooperation dynamics in LCM ISs (Shaft et al. 1997). ASG's creation of environmental performance as an overarching goal should reduce firms' tendencies to use political solutions to problems consistent with superordinate goal research (Sherif et al. 1961). (We should note that in this context, "political" refers to self-interested intrafirm or interfirm behavior on the part of organizational actors rather than actions in response to governments or public policy.) The larger goal diverts a firm's attention from its individual interests in political behavior to the collective need for improved environmental performance, thereby increasing cooperation. Research on interorganizational politics, however, suggests that when possible, firms use coercive sources of power (Pfeffer and Salancik 1978). Conversely, in a marketing channel relationship (which is conceptually similar to a physical life cycle of a product from the creation of inputs to final disposition of all outputs and waste), firms down the channel are more likely to be satisfied with the interorganizational relationship when noncoercive sources of power are used (Hunt and Nevin 1974). Currently, ASG has been noncoercive and has moved slowly in requiring firms to adhere to their environmental standards. Although all firms provide ASG with environmental performance information, ASG has not dropped any haulers because of poor environmental performance.

The final two issues we discussed above (conflicting goals and objectives, and power, control, and cooperation dynamics) are intertwined. ASG has used environmental performance to help create an overarching goal, thereby reducing conflicts between goals and objectives and helping engender cooperation. In essence, the recognition of an overarching goal assists in addressing both issues. It should be noted, however, that the quest to achieve an overarching goal does not preclude the use of coercive tactics, although it provides an alternative to the use of coercion to engender cooperation. Note that trust is critical to the success of interorganizational relationships such as that between ASG and its haulers (Morgan and Hunt 1994; Welty and Becerra-Fernandez 2001), as well as IOISs (Hart and Saunders 1998). Further, trust is undermined by the use of coercive power (Frost and Moussavi 1992). Hence, firms that wish to adopt LCM may find it beneficial to understand the relationship between goal congruence and cooperation dynamics and create complementary solutions to address them.

Two new issues for firms to consider when implementing LCM ISs arise from our analysis of ASG. First is ASG's ability to align environmental management efforts with their overall corporate strategy. This issue is analogous to the one many chief information officers face when they must provide the IS to support a firm's strategy but may not be involved in strategic planning activities. At the time this case was developed, ASG's environmental manager reported directly to the CEO. This reporting structure gave environmental issues similar visibility as other business issues. Because the environmental manager reported directly to the CEO, top management had a much more direct understanding of the environmental issues, threats, and opportunities that the firm, its customers, and its suppliers face. This allowed ASG to better integrate environmental management with the firm's overall strategy. Further, the direct reporting relationship between the environmental manager and the CEO is evidence of top management support of environmental strategies, which is important to achieving high levels of environmental performance (El Sawy et al. 1999; Walton et al. 1998). This reporting relationship may be a key factor in ASG's success in environmental management

and its willingness to allocate resources to the development of ISs to support environmental management. It should be noted that as ASG achieved some competitive advantage through environmental performance, key managers became increasingly supportive of the goals of environmental management efforts. Hence, a reciprocal relationship developed between the firm's achievement of competitive advantage through its environmental management efforts and top management's support of those efforts.

The second new issue is that LCM ISs may change the relationships between ISs within the firm. The inclusion of environmental performance information to customers as part of ASG's overall track-and-trace system is made possible by the external linkage with haulers and the addition of a linkage from ASG's internal MIS (which provides the aggregated environmental performance information) to ASG's TPS (track-and-trace system). This type of interrelationship is atypical, and one can only speculate how other IS relationships may be effected as ASG increases connectivity with haulers. Although it is difficult to predict what other changes may result, we believe that firms that are prepared to take advantage of new interfirm IS linkages by creating new intrafirm IS linkages are poised to achieve the greatest benefits. ASG's use of aggregated environmental performance information from haulers to give customers environmental performance based on specific routes is an example of the type of unique information that can be created to benefit customers that may, in turn, make customers less willing to switch to a competitor (Bakos 1991). Bakos (1991) argued, however, that the advantages created by new ISs frequently last only as long as it takes competitors to create similar systems. Therefore, it will be interesting to observe if ASG is able to exploit future IOIS linkages in a similar fashion, thus staying ahead of competitors.

Strengths and Limitations

A limitation of our study is the use of Mr. Swahn as the single informant during the interviews. As noted above, at the initiation of the study Mr. Swahn was solely responsible for environmental management, so he was the most able to discuss ASG's environmental manage-

ment practices. An additional reason to rely on Mr. Swahn is that he speaks fluent English. Therefore, we conducted the interviews directly rather than through an interpreter.

A major strength of this study is its longitudinal nature. We conducted three formal interviews over a span of four years. This provided a unique opportunity to observe the evolution of the inclusion of suppliers into ASG's environmental management efforts. Specifically, the environmental performance monitoring system transformed from a situation in which haulers provided environmental performance information through e-mail or on a diskette via surface mail into a circumstance in which all haulers provide the information via ASG's extranet. This information is now integrated into ASG's track-and-trace system.

A second strength of the study is the use of two interviewers. The first two authors (Shaft and Sharfman) conducted all interviews jointly. We were then able to see any issues raised during the interviews from multiple perspectives to increase the objectivity with which we wrote the case.

Conclusion and Implications

In this article we have described how ASG uses LCM ISs to support the firm's environmental and strategic efforts. We observed ASG using OASs and MISs interorganizationally as part of their environmental management efforts. The use of TPSs, DSSs, and EISs is less developed and appear to be internal rather than interorganizational. ASG has not developed linkages to support the exchange of environmental data, however, as posited by an earlier framework (Shaft et al. 1997); instead, environmental information is exchanged. Although the exchange of environmental information was noted as an essential element of LCM ISs (Shaft et al. 1997), the exchange of environmental information prior to environmental data was unanticipated.

Standardization and cost were raised as important issues in the development of LCM. It appears that focal firms should be prepared to take the steps to define the information to be exchanged and bear the cost of developing the ISs to support the exchange. These tasks appear

less onerous than anticipated, however, because of the use of the Internet to link organizations.

Other firms, however, should be aware of the issues of goal congruence and power dynamics. ASG has addressed these simultaneously by developing environmental performance as an overarching goal for itself and its haulers. A critical issue in the success of such efforts appears to be the development and maintenance of trust between ASG and its haulers. ASG has not used coercive tactics to achieve cooperation from their haulers, nor has it used the environmental information for nonenvironmental purposes.

A new issue raised by the present study is that ASG's ability to integrate the environmental function into the firm's strategic activities appears to have been positively effected by the nature of ASG's organizational structure. The environmental manager directly reported to the CEO. Therefore, environmental issues received a high profile and could be well integrated into ASG's strategic efforts.

Another new issue to consider in the development of LCM ISs is the change in the relationship between ASG's MISs and TPSs due to the integration of haulers' environmental information. Environmental performance information from suppliers becomes an input to ASG's track-and-trace system to provide environmental performance indicators for shipments. Firms need to be prepared to create new linkages between and among their own ISs to take maximum advantage of new IOIS relationships.

ASG views its current efforts to incorporate its suppliers into its environmental management efforts as a success. ASG has acquired new contracts and expanded existing ones because of its environmental performance and environmental IS. The company's environmental practices seem to have become a source of competitive advantage. Through its network of haulers, ASG has created a relatively unusual ability to monitor the environmental performance of its fleet and leveraged this ability by providing its customers with environmental performance information linked to specific shipments through ASG's track-and-trace system.

We suggest that one of the core elements of ASG's success in integrating suppliers into its environmental practices has been extensive use of

ISs to support environmental management. The company's commitment to the use of IT made the addition of environmental ISs more effective than may otherwise have been possible. We have focused on ASG's environmental ISs so that we could examine them in depth to better understand the role that ISs can play in environmental management efforts. It would be inappropriate, however, to conclude that such ISs exist in isolation. Rather, these ISs are an outgrowth of ASG's alignment of IT with its overall strategy (cf. El Sawy et al. 1999). ASG's ability to integrate its suppliers into its environmental monitoring system and utilize suppliers' performance information in ASG's own ISs provides insights into the opportunities that this type of integration provides.

It is reasonable to consider how this investigation of LCM ISs contributes to industrial ecology. In the 12 years since Frosch and Gallopoulos (1989) first coined the term "industrial ecosystems," there has been a wide range of work developed to articulate the concept. It is still not clear, however, what steps firms need to take to make the transition to industrial ecology. We argue that a necessary but not sufficient condition for firms to complete the transition to industrial ecology is the adoption of an LCM perspective (cf. Sharfman et al. 1997). LCM ISs are a critical part of LCM. The analysis we present of ASG's use of ISs to support environmental management efforts is instructive in further developing the theory and practice of industrial ecology through examination of this key element of the transition firms must make.

Notes

1. The proliferation of terms concerning managing the total physical system of a product or service can be a source of confusion for the reader. We first published the term "life-cycle-oriented environmental management" in 1996 (Sharfman et al. 1996) and were using it as early as 1993 (Sharfman and Ellington 1993). We developed the term to describe the management efforts that firms must undertake to address all of the physical system elements, from the creation of inputs to the disposition of outputs. Our term was meant to be inclusive of such terms as "chain management" and "integrated chain management,"

which connote management up and down the physical system life cycle but do not specify the environmental focus of our term. We also intended our term to include such ideas as “environmental supply chain management” and “supply chain environmental management.” Our term is broader because it includes the customer or output side in addition to the supply (input) side. In recent years, however, the simpler term “life-cycle management” has begun to gain favor and implies the environmental focus of our longer term. To be consistent with current practice, we use “life-cycle management” for the remainder of this article.

2. Agenda 21 is a comprehensive plan of action to be taken globally, nationally, and locally by organizations of the United Nations system, governments, and major nongovernmental organizations in every area in which humans affect the environment (cf. United Nations 2001b). It is an agreement by the signatory states to work toward sustainability in the twenty-first century. In Sweden particularly, many local governments have adopted Agenda 21 programs.
3. Expert systems were intentionally excluded from the framework because the expertise to address life-cycle-oriented environmental management is not yet well developed. We should note that there has been some recent work using more expert type ISs (e.g., Sousa et al. 2000) for life-cycle management. When this area of inquiry develops more fully, our typology will need modification accordingly.
4. Much MIS data are derived from TPSs; therefore, the EIS connection with the TPS is indirect.
5. ISs for LCM are expected to evolve into a set of more tightly linked systems. Because LCM is still in a relatively early stage of development, we omit the discussion of the tightly coupled configuration. See work by Shaft and colleagues (1997) for details about the tightly coupled configuration.

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