

Green Automotive Supply Chain for an Emerging Market

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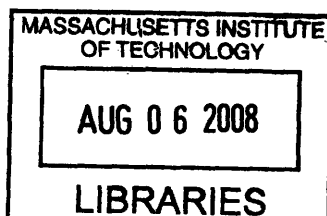
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Abstract

Green Supply Chain Management (GSCM) within the automotive industry is largely based on combining lean manufacturing with mandated supplier adoption of ISO14001-compliant Environmental Management Systems (EMS). This approach evolved from automotive manufacturers seeking to expediently expand green practices within existing lean supply chains. However, a new automotive enterprise, without the legacy issues of an existing supply chain, has the opportunity to customize its supply chain from scratch, to comprehensively achieve both financial and green objectives. This thesis investigated a more holistic approach to creating a financially-viable green automotive supply chain for the MIT Vehicle Design Summit (VDS) – a start-up enterprise planning to enter the Indian emerging market with a new type of eco-friendly automobile. First, a hypothetical VDS supply chain was postulated by analyzing the contextual challenges of the Indian emerging economy, so as to optimize the location, supplier selection and manufacturing models within its business context. To ensure that the capital investments needed to fulfill the supply chain’s green objectives do not compromise its primary purpose of value creation, a Triple Bottom Line technique called Environmental Cost Accounting was used as a managerial decision tool, which demonstrated the financial viability of GSCM for VDS. Next, green solutions for each supply chain function were identified for integration into the hypothetical supply chain. It was found that many important green solutions for an automotive supply chain like supplier selection, concurrent engineering, cascading of lean production best practices to the extended supply chain, fuel-efficient transport practices and green infrastructure design, have already been developed by various governmental and non-governmental agencies. Also, product recovery through End-of-Life Vehicle (ELV) processing was identified as a vital green supply chain function required for closing the loop between sales and sourcing. The key issue was integrating these disparate solutions into a holistic environmental management framework for VDS to implement and sustain. This was accomplished using an ISO14001-based EMS as the master plan. The developed EMS Manual is a pioneering document that leverages chain-wide participation in existing green initiatives like the Green Suppliers Network, SmartWay Transport Partnership and LEED Green Building Rating, to realize a green supply chain by ensuring continuous monitoring and improvement of the implemented initiatives.

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“We get some of our best results from letting fools rush in where angels fear to tread.”

- My Life and Work by Henry Ford

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Chapter 1 Introduction

This thesis presents the work done to develop a ‘green’¹ automotive supply chain for a potential start-up company seeking to enter an emerging market. The authors of this thesis are members of the supply chain development team of the MIT Vehicle Design Summit (VDS). VDS is a student-led initiative that aims to: 1) Provide solutions for maximizing the Earth’s energy resources, and 2) Propagate awareness of the need for energy conservation. As part of its effort to fulfill these objectives, VDS is in the process of developing an energy-efficient car called the Vision 200 which it intends to produce and launch in India in the near future. To do so, VDS will incorporate itself as a start-up company and establish manufacturing/assembly facilities in a major Indian city.

Recognizing that the ‘green’ ideals of the Vision 200 energy-efficient car may be compromised by the pollution generated in the process of bringing it to market, VDS seeks to align the supply chain’s environmental impact with the car’s ‘green’ purpose. This is the motivation for this thesis.

1.1 Background of MIT VDS and the Vision 200 Car

MIT VDS was started in 2006 and comprises an international multi-disciplinary team formed around an “open-source virtual and physical environment that will enable collaborative development of core technologies to seed further development” (VDS, 2007). VDS draws together top research teams from universities around the world to leverage their respective areas of expertise in the common goal of catalyzing a global race to promote widespread clean energy usage – what VDS calls an *Energy Space Race* (to capture the passion and verve defining the Space Race of the 1960s). Presently, it derives its funding from corporate sponsors interested in

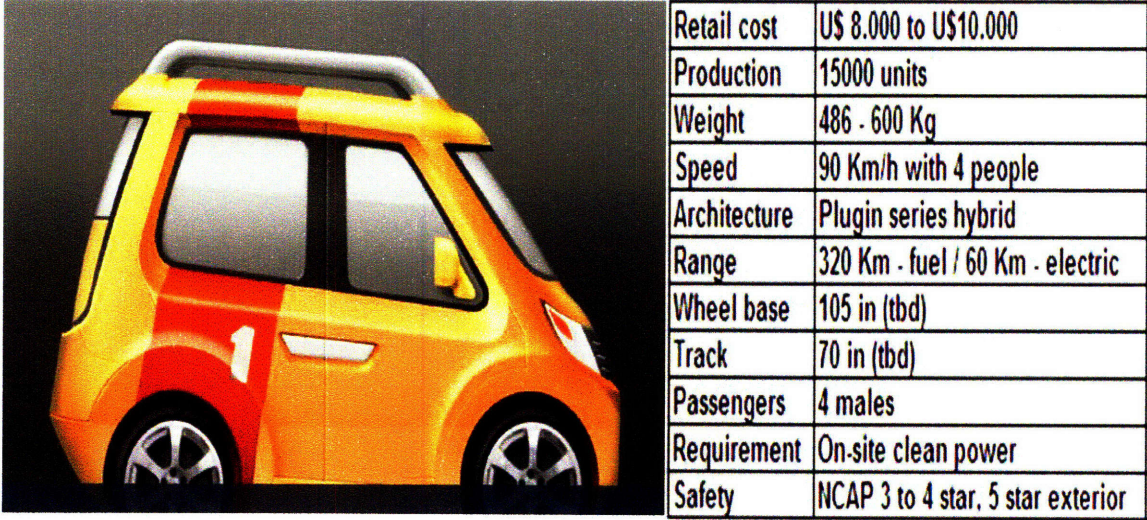
¹ Broadly, ‘green’ is defined as environmentally-friendly. The definition of a ‘green’ automotive supply chain is one that minimizes negative impact to the environment by reducing pollution of all forms (See section 2.2 for details).

its mission. However, for production and marketing of the Vision 200, VDS plans to seek venture capital funding as a start-up company, or start a joint venture with a larger automotive manufacturer.

Described as a “hyper-efficient 4-6 passenger vehicle earmarked for India that will demonstrate a 95% reduction in embodied energy, materials and toxicity”, the Vision 200 is the technological platform for advancing VDS’ agenda of catalyzing an Energy Space Race. Key features of the Vision 200 include:

1. Use of the lowest possible amount of energy and materials in its production
2. Fuel economy of at least 200 mpg (miles per gallon)
3. Capable of going from 0-60 mph in less than 10 seconds, has a 200-mile range, and top speed of 100 mph

As of January 2008, VDS targets an initial annual production run of 5,000 units over a 3-year period, for a total of 15,000 units. Production is only expected to begin in 2011, at the earliest.



Source: MIT Vehicle Design Summit

Figure 1: The VDS Vision 200

1.2 Research Approach

While the Vision 200 is still under development and many of its technical specifications have yet to be finalized, it is possible to begin exploring the issues and requirements of a ‘green’ supply chain at this stage by separating the *product’s* ‘green’ attributes from the environmental impact of the *processes required to bring it to market*. This thesis will thus avoid discussion of product development issues like materials selection, and focus instead on the supply chain functions defined below.

1.2.1 Supply Chain Definition

There are two perspectives by which a supply chain can be defined: 1) Based on *physical elements*, and 2) Based on *function*. Based on a *physical* perspective, a supply chain is defined as: “*a network of facilities and distribution options that performs the functions of procurement of materials, transformation of these materials into intermediate and finished products, and the distribution of these finished products to customers.*” (Ganeshan & Harrison, 1995).

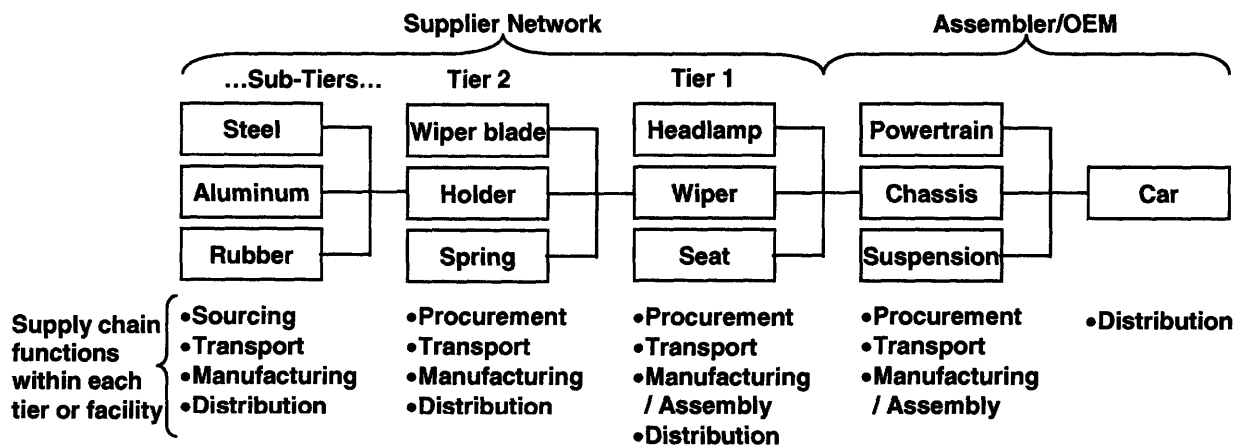


Figure 2: Physical perspective of a supply chain

An example of the physical perspective is shown in figure 2. This is useful for visualizing the supply chain echelons (i.e. supplier tiers), but is less useful for understanding the activities involved in each tier and does not convey the supply chain’s value creation well.

Based on a *functional* perspective, a supply chain is defined as: “*a sequence of events in a goods flow which adds to the value of a specific good.*” (EyeforTransport, 2008) The “sequence of events” referred to in the latter definition are the “functions of procurement of materials, transformation of these materials into intermediate and finished products, and the distribution of these finished products to customers” mentioned in the first definition. Additionally, the Council of Supply Chain Management Professionals (CSCMP), the professional association for supply chain practitioners, describe the meaning of supply chain as: “*To create a competitive advantage through purchasing, manufacturing, and distributing products and services, which provide superior value to customers.*” (Council of Supply Chain Management Professionals, 2008) Essentially, this means the movement of goods and services to the consumer. It should also be noted that the last two definitions of a supply chain incorporate value-addition as a characteristic. Thus, all three definitions describe a supply chain as comprising of the following top-level functions/events/processes: Sourcing/Purchasing, Manufacturing/Assembly and Distribution/Sales.



Figure 3: Functional perspective of a supply chain

Further, the main activity linking the above supply chain functions is Transportation (i.e. flow or movement of goods from one supply chain process to the next).

Hence, in dealing with the VDS supply chain, we will base our treatment in terms of the above four functions of **Sourcing/Purchasing, Manufacturing/Assembly, Distribution/Sales** and **Transportation**. This *functional* perspective of a supply chain is the most appropriate approach to use for the research topic, as the automotive supply chain’s environmental impact stems from the activities within each of these functions.

1.2.2 Statement of Research Problem

Since supply chains must be designed for a company's specific business and operating context to deliver value, the research problem is also framed by two key aspects of VDS: 1) Its status as a potential start-up company with limited resources, and 2) Its targeted business environment in the emerging economy of India.

Finally, the key management tool used by companies to monitor and control environmental performance is the environmental management system (EMS). An EMS is a system that addresses potential environmental impact and provides an organized approach to management decisions based on business needs, resources, and facility-specific goals (Darnall, Jolley, & Handfield, 2008).

Putting together the above, the research problem can be stated as follows: **To develop a green automotive supply chain for a start-up company planning to enter an emerging market, using an environmental management system optimized for its business context and scope.**

1.3 Scope

First, the financial viability of a start-up company like VDS implementing a green supply chain in India needs to be established. This is done by studying the Indian automotive business environment to determine the impact of key issues like government policies, costs, tariffs, environmental regulations etc., on the VDS value chain. This is to assess the conduciveness of the Indian business environment to running a green automotive supply chain. This basic step is important because the strategic function of a supply chain is to add value to the business and stretch objectives like environmental performance must not detract from this purpose.

Next, a hypothetical VDS supply chain will be postulated based on existing lean production supply chains used by Toyota and General Motors (GM). These two automotive companies are selected because Toyota is recognized as having the best lean production supply chain in the automotive industry, while GM has the most experience with establishing automotive supply chains in emerging economies. This hypothetical supply chain will incorporate all the necessary elements for VDS' intended operations in India, but without the 'green' features initially.

With the hypothetical VDS supply chain, we can proceed to develop 'green' solutions based on information obtained about the most environmentally-unfriendly segments of the supply chain and the gaps indentified on efforts to green the entire supply chain. This will be achieved in stages: First, the environmental management processes presently used by automotive manufacturers will be mapped to each applicable segment of the hypothetical VDS supply chain. Next, for those segments that do not have any existing environmental management solutions (i.e. the gaps), suitable frameworks will be adapted from environmental management initiatives identified from regulatory VDS agencies or non-automotive related industries. The performance metrics of the environmental management frameworks to be adapted or developed will be scrutinized to determine their suitability for filling the gaps.

Finally, based on the assembled set of environmental management frameworks and solutions, an EMS aligned to the ISO14001 standard will be developed for VDS as the master plan for achieving a green supply chain for its operations in India. To develop this EMS, certain assumptions about the organizational structure of the potential VDS start-up company will be made in consultation with the VDS leadership.

1.4 Thesis Scope

This chapter has covered the background, current situation, motivation and approach of the project to develop a green automotive supply chain for VDS. It has also identified the specific research problem of this thesis in the preceding section. The remaining chapters of the thesis are devoted to the following:

1. In Chapter 2, a review of the relevant literature is undertaken to place this research in the context of prior work done in green supply chain development, and to illuminate the direction for research
2. In Chapter 3, the economics of deploying a green supply chain in an emerging market is investigated by studying India's business environment. This is to ensure that the primary objective of a supply chain – to add value to the business – is not sacrificed in the pursuit of stretch objectives like environmental performance
3. In Chapter 4, a hypothetical supply chain for VDS is postulated and used as the basis for developing the necessary solutions to 'green' it
4. In Chapter 5, specific 'green' solutions are identified and proposed for each function of the hypothetical supply chain
5. In Chapter 6, the entire set of 'green' solutions are incorporated into an EMS based on the ISO14001 standard – resulting in a master plan for managing the green VDS supply chain designed for the Indian emerging market

Chapter 2 Literature Review

The research question was defined in Chapter 1 as “developing a green automotive supply chain for a start-up company planning to enter an emerging market”. A thorough search of the existing body of literature revealed nothing pertaining to this specific research question. Thus, this thesis will be the first to address the specific issue of how a start-up automotive company can best develop and manage a ‘green’ supply chain for operations in an emerging market. However, a review of existing literature related to the research question is still useful for establishing the research parameters and to glean potential approaches for investigating the research problem. The boundaries for this literature review were established by considering the following four key elements contained within the research problem:

1. The structure of an automotive supply chain and the value it brings to the business
2. What constitutes ‘green’ within the context of automotive supply chains, and existing examples of a ‘green’ automotive supply chain, if any
3. The relevant metrics for measuring the defined standard of ‘green-ness’ and how automotive companies have implemented such metrics
4. Supply chain operations in emerging markets and the differences, if any, from those in developed markets

This chapter presents the findings from investigating the above topics and illuminates the direction for research. It is organized into the four sections described below and concludes with a summary section.

First, to understand the structure of automotive supply chains and their value, a survey of automotive manufacturing and its evolution is undertaken. As a key link in the chain of activities

required to bring a car to the end-consumer, the manufacturing process determines the demands placed on the supply chain and has the largest influence on the overall environmental impact of the automotive business. This section aims to appreciate how automotive supply chains are affected by the type of production system they serve, and to obtain a suitable model for the VDS supply chain, minus the 'green' aspect. It is likely that designing a green supply chain for VDS also requires recommending the type of manufacturing system to be adopted, in order to ensure that the supply chain continues to serve its primary function of delivering financial value.

Second, due to the lack of a formal, internationally-recognized definition of the term 'green' (Richmond, 2007), it is necessary to establish one for the context of this research. The aim is to identify the various ways by which an automotive supply chain can negatively impact the environment and to encapsulate the solution to these negative effects in the definition of 'green' for this thesis. Another aim is to determine if there are any existing models of a 'green' automotive supply chain – especially one for a start-up company operating in an emerging market.

Third, after establishing what constitutes 'green' in the context of automotive supply chains and determining a suitable supply chain model for VDS, it becomes appropriate to explore relevant metrics to use in measuring the environmental performance of such a supply chain. This step is necessary for finding ways of integrating the 'green' aspect into the selected supply chain model for VDS. A survey of existing green standards will also be useful in determining the best way to design the environmental management system to be proposed for VDS, and whether existing metrics are adequate for its purpose.

Finally, the challenges faced by a start-up company are legion. The desire by VDS to debut its inaugural product in an emerging market presents additional challenges that must be understood for their unique consequences on the supply chain and its environmental impact. It is also important to reconcile the complexities of supply chain operations in emerging markets with the limited resources of a start-up company. This is to ensure the practicality of the solution developed for start-ups like VDS.

2.1 Structure of an Automotive Supply Chain

Womack et al. (2007) describe two distinct types of automotive supply chains depending on the type of manufacturing system served. In the first, a *mass production* system, the supply chain tends to be complicated and unstructured with thousands of suppliers on short-term contracts to supply parts to the automotive assembler or original equipment manufacturer (OEM).

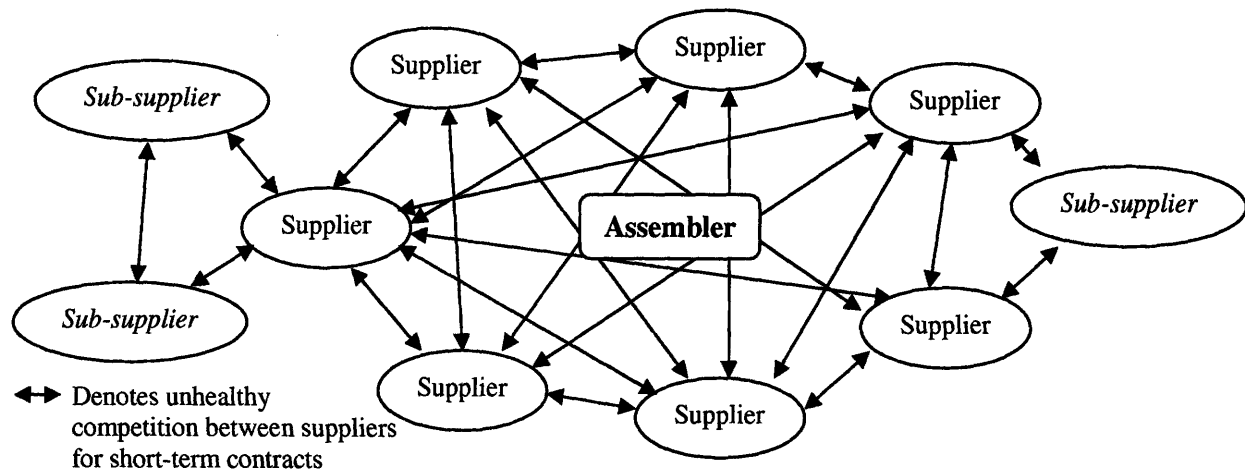


Figure 4: Diagram of mass production automotive supply chain

Often, the mass production automotive assembler would undertake the component design entirely in-house with its own design engineers and give only the component blue print to the

lowest bidder to manufacture on a contract basis. Such a system inevitably results in the following:-

- i. Quality problems stemming from dimensional or material mismatch when the various parts produced by different suppliers are assembled into a higher-level component
- ii. Suppliers submitting initial low bids to secure the contract while fully intending to raise prices as the assembler becomes reliant on them. Some suppliers under-bid on contracts and go bankrupt, causing disruption to the OEM's operations.
- iii. Lack of transparency between suppliers and assemblers, with suppliers refusing to share their operational procedures and competencies with assemblers for fear of compromising their contract bargaining positions
- iv. Non-sharing of best practices resulting in resources wasted in 'reinventing the wheel'

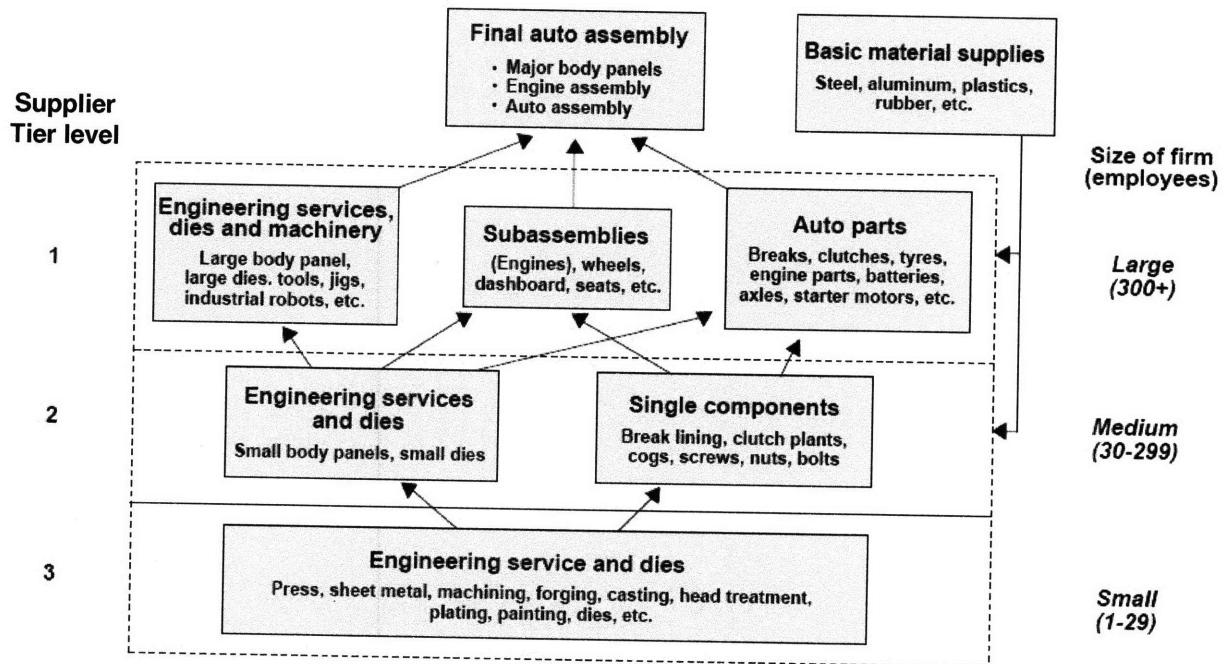
Thus, the relationship between mass producers and their suppliers is arms-length at best, adversarial and characterized by mutual mistrust at worst. Mass production automotive supply chains were dominant from the time of Henry Ford's Model "T" till the early 1980s, and were widely used by all the major Western automotive manufacturers. They required large production scales and the companies that experienced some success with mass production supply chains were also usually more vertically-integrated (i.e. performed more functions in-house and used limited design out-sourcing). This makes it unsuitable for a start-up like VDS, since it has limited resources to design and build many components in-house, and also because the initial VDS Vision 200 production run is only for 15,000 units.

Fortunately, other start-up automotive companies had encountered the same issues now faced by VDS. Given the problems associated with the mass production system of automotive

manufacturing and supply chain management, a fledgling Japanese automotive manufacturer in the 1950s – Toyota Motors – decided against adopting it and instead developed its own system, called the Toyota Production System, but better known today as *lean production* (Liker, 2004). In contrast to mass producers, lean producers like Toyota treat their suppliers as partners and integral elements of their production system. Suppliers are involved in the design of products from the onset and trained in ways to reduce setup times, machine breakdowns, inventories and defects, and take responsibility to deliver their best possible parts. Supplier relationships in lean production have the following characteristics:-

- i. Virtual integration, as opposed to traditional vertical "contractor-subcontractor" integration, whereby culturally different value-added relationships between manufacturers and suppliers are forged. Japanese automotive manufacturers even acquire equity stakes in their Tier 1 suppliers to demonstrate their commitment to them
- ii. Trust and sharing of economic benefits accruing from process improvements and waste elimination
- iii. Proactive, mutual interest in each other's success. Lean producers and their suppliers exchange staff regularly on projects and the close interaction promotes cross-learning and understanding of each other's needs

To form such close, high-value supplier relationships, lean producers select their Tier 1 suppliers very carefully with the aim of forging a long-term partnership. Thus, lean producers deal only with their Tier 1 suppliers, and encourage them to form, in turn, similar close relationships with their Tier 1 suppliers – resulting in lean supply chains having well-defined tiered structures compared to traditional mass production supply chains (Womack, Jones, & Roos, 2007).



Source: United Nations ESCAP

Figure 5: Physical perspective of lean production automotive supply chain

Such lean production supply chains are better suited for VDS and their model provides the framework to develop the VDS green supply chain. Womack et al. (2007) also describe lean production supply chains as being up to 80% more efficient than mass production supply chains due to the focus on continuous improvement (*kaizen*) and elimination of the 7 key wastes² (*muda*) in the lean production system. Thus, as part of the green supply chain solution, there is also a need to investigate how VDS can incorporate lean production principles into its own manufacturing system in order to derive maximum value.

2.2 Defining a ‘Green’ Supply Chain

The first step in creating a ‘green’ supply chain is to establish a clear understanding of what ‘green’ means. Richmond (2007) observed that different environmental interest groups each have their own narrow interpretation of what constitutes ‘green’. More recently, organizations

² The 7 key wastes in a production system identified by Taiichi Ohno, creator of the Toyota Production System, are Inventory, Defects, Overproduction, Transportation, Waiting, Overprocessing and Motion.

championing the carbon footprinting agenda, like the Green House Gas (GHG) Protocol Initiative and the Carbon Trust, have usurped the term 'green' to connote any activity that is 'carbon-neutral' (i.e. having zero total carbon release, brought about by balancing the amount of carbon released with the amount sequestered or offset) (World Resources Institute and World Business Council for Sustainable Development, 2004). This, however, is not aligned with the full scope of the automotive industry's interest in 'greening' their operations. According to the Business for Social Responsibility (Business for Social Responsibility Education Fund, 2001), automotive industry suppliers report that automotive manufacturers are mainly concerned about the inclusion of restricted substances (e.g. lead, cadmium) into their components and also that their suppliers have environmental management systems that prevent pollution of the air, land and water of the communities they operate in. This alludes to a much wider definition of 'green' for the automotive supply chain to encompass freedom from any form of environmental pollution – and not just atmospheric.

Further, some automotive manufacturers like Volkswagen AG have even employed the term 'green' to describe a spectrum of environmentally- and socially-responsible measures from cleaner production to sustainable manufacturing (Koplin, Seuring, & Mesterharm, 2007). Sustainable manufacturing is described as encompassing socially-conscious activities that are also considered 'green', such as adopting workforce equality, avoiding worker exploitation and other manpower issues. However, this all-encompassing interpretation of 'green' is politically-charged – especially considering the differences in attitudes with regards to workforce rights and globalization between developed and emerging economies (World Bank, 2004).

Thus, literature on existing 'green' automotive supply chains indicate that the automotive industry considers 'green' to encompass all measures that reduce pollution in all forms, with some going as far as to associate 'green' with 'socially-sustainable' activities. Considering VDS' organizational vision of 'catalyzing an Energy Space Race' and the environmental focus of the Vision 200 car, this thesis will confine its definition of a 'green' automotive supply chain to one that minimizes negative impact to the environment by reducing pollution of all forms.

2.3 Metrics and Standards for Measuring Environmental Impact

As mentioned in section 2.2, a lean production supply chain is inherently 'green' due to the principles of the lean manufacturing system it supports (i.e. pollution minimization through continuous waste reduction). However, this raises the next logical question of the comprehensiveness and effectiveness of a lean supply chain's green qualities (i.e. how green is lean?). To answer this question, it is necessary to look at the standards used by the automotive industry's major lean producers to measure their environmental performance. This will aid in determining the metrics to include in the environmental management system for VDS' lean supply chain.

According to Prakash and Potoski (2006), ISO14001 is the most widely adopted environmental management standard in the world today. Launched in October 1996, ISO14001 is an international standard administered by the International Organization for Standardization designed to assist organizations in minimizing the environmental impact of their operations. It is a process-based standard rather than an outcome-based standard. It does not prescribe guidelines for organizations to follow *per se*, but consists of a framework designed to assist subscribing

organizations to design their own environmental management policy, system and structure, and to ensure compliance with the developed policy. Although the standards do not prescribe performance levels, it has been shown that performance improvements will invariably be achieved by any organization that continually emphasizes its commitment to environmental care, and whose employees are trained and aware of the policies in place to protect the environment (International Organization for Standardization, 2008). As of 2005, over 88,000 companies have certified their environmental management systems to the ISO14001 standard to prove their commitment to protecting the environment – making ISO14001 the gold standard in ‘green’ (Prakash & Potoski, *The Voluntary Environmentalists*, 2006).

Since 2003, the ‘Big Three’ US automotive manufacturers have required all of their own and their Tier 1 suppliers’ facilities to be ISO14001 accredited. Other major international automotive manufacturers have since followed suit and this has made ISO14001 the *de facto* standard for certifying the quality of EMSs in the automotive industry. Given the wide-spread recognition and comprehensiveness of ISO14001, VDS cannot afford to ignore it. It has been estimated that the cost of ISO14001 certification can range from \$25,000 to \$100,000 per facility depending on size (Kolk, 2000). Assuming VDS starts with a limited car assembly facility with an annual production capacity of 5000 units (small by general automotive industry standards), it is reasonable to estimate that it would be at the lower end of the range. Thus, getting its EMS certified to the ISO14001 ‘gold’ standard is both a practical and affordable investment for VDS, and this research will focus on aligning the proposed EMS for VDS to the ISO14001 standard.

Because ISO14001 is a process-based standard, automotive manufacturers have been focusing mainly on improving the environmental performance of their own operations and that of their Tier 1 suppliers when they attempt to extend ISO14001 adoption (IHS Automotive Industry Trends, 2006). Measuring the environmental impact of activities in the links *between* the supply chain tiers has not received as much attention. Also, few automotive manufacturers have focused on the downstream aspect of their supply chain, viewing the consumer as the final link and not developing the product recovery function of their value chain. To develop a comprehensive green supply chain, our research must also focus on these less well understood automotive supply chain functions.

2.4 Supply Chain Operations in Emerging Markets

VDS intends to launch the Vision 200 in India, the world's second largest emerging economy after China. This entails establishing a manufacturing/assembly plant and a local supplier network for components that can be sourced more cheaply in-country. While the exact percentage of Vision 200 components to be obtained from local Indian suppliers has yet to be determined, it is reasonable to assume that it would be at least 50% in terms of weight. Since VDS' operations in India will involve interaction with many facets of Indian economy and society, understanding the peculiarities of the Indian emerging market will help in designing VDS' green supply chain to deal with these challenges.

As noted by Swaminathan (2007), the main challenge confronting foreign companies seeking to operate in India is its undeveloped transportation and technical infrastructure. While urban road networks in cities like Bangalore, New Delhi and Mumbai are adequate and improving, the quality of inter-state highways is poor and prone to frequent disruptions by the severe Indian

monsoons. Power and information technology infrastructure to outlying metropolitan suburbs are also not fully developed or stable. In terms of the supplier base, there is a huge difference between the capabilities of large top-tier and smaller, rural, lower tier suppliers (Swaminathan, 2007). According to Balakrishnan et al. (2006), India has the largest number of companies conferred with the coveted Deming prize for major advances in quality improvement. However, these have all been awarded to the large top-tier suppliers, and the majority of Indian suppliers lack critical elements of service in terms of quality, delivery reliability and value-addition (Balakrishnan, Iyer, Seshadri, & Sheopuri, 2006). Compounding the problem of inadequate highway infrastructure, Sastry and Chandra (2002) estimate that only 4% of Indian suppliers are located within 3 miles of the manufacturing facilities they support, while more than 50% are located beyond 300 miles – probably to leverage on the lower costs in the rural areas. Finally, the cultural and language diversity within India is another complication not to be underestimated.

Foreign manufacturers have attempted to circumvent some of these problems by creating joint ventures with their Indian suppliers, or acquiring stakes in them and transferring technology (Sastry & Chandra, 2002). While this approach has worked for the large multinationals and their large Indian suppliers, it is not likely to be feasible for a start-up company like VDS. Thus, in selecting local suppliers for VDS' supply chain, factors such as distance, quality, reliability, ease of communication and number of suppliers to engage are pertinent for the context of the Indian emerging market.

2.5 Summary

This chapter has presented the two main types of automotive supply chains and explained why VDS should model its supply chain on the lean manufacturing version. This necessitates VDS adopting lean production methods as part of its strategy to green its supply chain. The definition of ‘green’ in the context of automotive supply chains, and for the purpose of this thesis, has also been established as that which minimizes negative impact to the environment through reducing pollution of all kinds across the entire supply chain. The chapter also described ISO14001 as the ‘gold’ standard currently used by the automotive industry to certify the effectiveness of the environmental management systems used by both manufacturers and suppliers. It showed, however, that ISO14001 does not prescribe the specific metrics for measuring environmental performance but is a good framework for ensuring that companies have a sound process in place for doing so. Section 2.3 also highlighted the links between supply chain tiers and the downstream product recovery as additional areas to target for green-ing the automotive supply chain. Finally, the challenges of inadequate infrastructure, disparate supplier capabilities and cultural and linguistic diversity in the Indian emerging market were presented as the key issues VDS needs to plan for in designing its supply chain.

In the next chapter, we will assess the economics of establishing a green supply chain in India as the first step to developing a hypothetical supply chain for VDS’ operations there. Knowing the financial resources involved will help us to determine the best approach for tackling the focus areas identified through the literature review (i.e. *how* to green VDS’ supply chain). This will be followed by a description of the solutions themselves and our proposal for building them into a green automotive supply chain for VDS (i.e. *what* VDS’ green supply chain will look like).

Chapter 3 Economics of Green Supply Chain Management in India

As a rule of thumb, about 70% of the total supply chain cost is fixed during the supply chain network design stage (Streamline Supply Chain, 2008). VDS, as a start-up company, thus has a unique opportunity to minimize its supply chain cost from the very beginning. However, there is a need to determine if there are additional costs involved in establishing a *green* supply chain compared to a regular supply chain in India. This helps to confirm if it is: 1) financially sensible for VDS to attempt green supply chain management in India, and 2) the best approach for doing so.

To address any cost differential between green and non-green supply chains, we first recall the elements of what makes a supply chain 'green'. It was mentioned in chapter 2 that a lean production supply chain is a green supply chain, since lean production achieves the green objective by continuous identification and elimination of waste. Thus, the cost of establishing a green supply chain can be factored by studying the cost of establishing a lean supply chain with minimal waste.

As the world's second-largest emerging economy, India offers intrepid investors the opportunity of accessing a market that is one-sixth of humanity. Specifically for the automotive industry, the Indian government has ear-marked this sector as a key pillar of India's industrial development plans and has launched the Automotive Mission Plan (AMP) in 2006 as the roadmap to achieving its goal of providing employment to 25 million Indians within this industry by 2016. An analysis of the Indian automotive industry is given in Appendix A to provide information on the key issues and driving factors behind this new focus area of India's economy.

The economics of establishing a lean supply chain in India depend on how its operations will be impacted by the unique characteristics of the Indian emerging economy. These were investigated

in the literature review, and showed that VDS needs to focus on designing a supply chain network that can overcome the undeveloped Indian physical and IT infrastructure, includes reliable local suppliers and has well-located key facilities. Interestingly, these factors correspond with the findings of a study on the key cost drivers of a supply chain to support manufacturing outsourcing to emerging economies. The study by Flextronics identified manufacturing capital costs, local taxes, warehousing and internal transportation costs as the paramount cost drivers (Dowling, 2004). The following sections will evaluate the economic implications of each of these factors based on the characteristics of India, so as to gauge the total cost of establishing a lean and green supply chain.

3.1 Economic Implications of Facility Location

To minimize tax exposure, warehousing and internal transportation costs, VDS should locate its assembly/manufacturing facility in Indian states offering attractive corporate tax and statutory incentives to encourage foreign direct investment. For example, many manufacturing companies have recently shifted operations to Baddi and Uttarnchal in northern India to take advantage of the tax holidays offered. This is despite the cost of having to re-design their existing supply chains, indicating how substantial the economic gains are. The recent introduction of state-specific Value-Added Tax and the elimination of the old Central Sales Tax³, is another impetus for companies to re-locate their operations and re-align their supply chains.

VDS, as a new entrant to India, would have no such supply chain network re-design cost, and can minimize its supply chain cost from the outset by optimizing the location of its manufacturing operations.

³ Central Sales Tax is generally payable on the sale of all goods by a dealer in the course of inter-state Trade or commerce or, outside a State or, in the course of import into, or export from, India.

3.2 Economic Implications of Network Design

Chapter 2 identified the links between the automotive supply chain tiers as a focus area for minimizing environmental impact. Although transportation costs currently only comprise about 10% of an automotive supply chain's operating cost, the increase in inbound and outbound freight stemming from globalized supply chain activities will increase this further (i2, 2007). A good network design, starting with an optimized location of its manufacturing facility, can minimize transportation and distribution costs by rationalizing all upstream and downstream parts/product movements. For example, land transportation of inbound and outbound freight can be minimized by locating the manufacturing/assembly facility at or close to shipping ports – a strategy employed by Toyota Motors.

3.3 Economic Implications of Green Capital Expenditure

Manufacturing capital costs are the largest fixed costs a new manufacturer like VDS would have to contend with. The focus on minimizing environmental impact necessitates additional capital investment in green technologies for building design and construction, manufacturing waste treatment and pollution control. The technology of eco-friendly machinery, like low-power consumption equipment, also tends to cost more than conventional equipment. Thus, a new manufacturer committed to adopting environmentally-friendly practices needs to find a way to quantify and justify the costs of going green to its investors. The need for such 'green accounting' tools to justify environmentally-motivated corporate investments have given rise to new management accounting concepts like the Triple Bottom Line⁴ (TBL) as new dimensions of measuring corporate performance. To the extent that environmental costs exist in every phase of a business' operations, Environmental Accounting (EA) provides a powerful tool to support

⁴ The Triple Bottom Line (or People, Planet, Profits) captures an expanded spectrum of criteria for measuring corporate success. Companies committed to corporate social responsibility often use some form of TBL reporting.

improved decision-making in product/process costing, capital investment decisions and strategic planning. EA is broad-based term that refers to the incorporation of environmental costs and information into a variety of accounting practices. In the next section, we introduce and use one of these EA tools – Environmental Cost Accounting (ECA) – to demonstrate the economic viability of running a green supply chain in India.

3.4 Environmental Cost Accounting

Environmental Cost Accounting (ECA) combines two fields of environmental accounting – Financial environmental accounting and Managerial environmental accounting – to support internal management decision-making with respect to corporate environmental expenditure. In its simplest form, ECA (incorporated into Generally Accepted Accounting Principles), is the practice by which corporations account for material and environmental costs by the identification, collection, analysis, and use of two types of information for internal decision making: 1) Physical information on the use, flows and fates of energy, water and materials (including wastes) and 2) Monetary information on environmental-related costs, earnings and savings. Basically, it is a breakdown of how environmental initiatives factor as costs to the corporation. Since the fixed manufacturing capital costs are absorbed as overheads into the material costs, ECA indirectly treats these costs as well.

To evaluate material costs, the flow of goods through the supply chain is followed to evaluate the cost of all activities required to bring the product to market, by factoring the impact of the company's environmental-related decisions. Historically, these can be hidden (for malicious intentions or just ease of accounting) in overhead accounts and generically termed as “Material Costs”. Often, corporations try to identify environmental costs without realizing their true source. This leads to decisions based on incomplete knowledge. Segregating these costs into

various types for analysis provides a more complete picture of the product's true cost (Graff, Reiskin, White, & Bidwell, 1998). On a case by case basis, the corporation should study the price elasticity of a green product (i.e. how much more customers would be willing to pay for it). This is where the cost segregation framework of ECA becomes critical, as although green capital investments may seem to be extraneous costs from an initial viewpoint, they may in fact represent an opportunity to achieve an increase in revenues or limit exposure to significant back end costs and liabilities.

To study the significance of these costs, Graff, Reiskin, White and Bidwell (1998) evaluated 39 cases from companies spanning various industry sectors like Chemicals, Metals, Printing, Electronics, Paper, Electrical Utilities and Automotive Manufacturing. The size of the sample was also varied and ranged from firms that have fewer than 20 employees to multi-billion dollar corporations that supply products to intermediate and end-customers. The investment in green initiatives proved financially rewarding – with all but two of the companies receiving a payback within 3 years, and the remaining two within 5 years of the initial investment. To evaluate the financial impact of green capital investments in the automotive manufacturing industry, we focused on the two cases from this industry. But first, a discussion of the ECA framework used is necessary, and described in the next section.

3.4.1 Analyzing Environmental Costs

Traditional accounting methods often do not record environmental costs, losses or benefits as they do not include external costs to the firm. To calculate the full environmental cost, ECA involves distinguishing a company's environmental costs into internal (i.e. those borne by the organization) and external (i.e. those passed on to society, like ecological and health damage) environmental costs. The internal environmental costs to the firm are further segmented into

direct costs, indirect costs, and contingent costs. Thus, ECA may be simplified as follows:

$$\textit{Full environmental costs} = (\textit{Internal costs} + \textit{External costs})$$

where $\textit{Internal costs} = (\text{Direct costs} + \text{Indirect costs} + \text{Contingent costs})$

$\textit{External costs} = \text{the costs of external environmental and health damage}$

The US EPA has structured the above costs into a five-tiered ECA framework described below and depicted in Table 1.

3.4.2 Internal Direct Environmental Costs – Tier 1

Direct costs are comprised primarily of process equipment, materials and labor (Whiting, 2003). These costs are the simplest to identify within the group as the costs are primarily up-front liabilities, like VDS' fixed manufacturing capital costs. When addressing these items, the profit and loss statement of the firm will usually incorporate them directly into the general categories of "Property, Plant & Equipment" or "Salaries/Employee Overhead". However, the latter is often not sub-categorized by segment, so although a direct cost may be clear about distinguishing the Property, Plant & Equipment costs of non-green and green solutions, the labor costs involved may be ambiguous and will typically receive little attention other than a footnote on the bottom of the P&L statement for an unusually large amount, if any. If year-over-year costs do not exhibit a great disparity, then the allocation would most likely go unnoticed.

3.4.3 Internal Indirect Environmental Costs – Tier 2

These costs are primarily paperwork expenditures, monitoring costs and permit requirements associated with environmental regulation compliance (Whiting, 2003). The standard accounting practice in this case is to bundle the entailed labor cost into a salaried line item, as the income statement of a firm doesn't typically acknowledge in what capacity or percentage of time the

employee spends on specific tasks. It should be noted that this can be detrimental to a firm's ability to conduct business in certain environments. For example, a small business like VDS may not have the resources to allocate towards the hours of paperwork involved with the monitoring of processes or expenditures necessary to participate in an industry sensitive to high liability exposure.

3.4.4 Liability Costs – Tier 3

These are primarily penalties and fines levied to the corporation or future liabilities that stem from litigation and such (Whiting, 2003). These costs are difficult to predict because of the limited amount of information a corporation has about future liabilities. When such a situation does arise, these costs would again be lumped into an ambiguous litigation or corporate overhead line item. This is problematic because legal costs are not an unfamiliar line item in large companies. As with the earlier types of costs discussed in this tier system, environmental-related liability costs are not specifically outlined to the decision makers.

3.4.5 Contingent Costs – Tier 4

These are intangible environmental costs that revolve around how the company is perceived, its relations with internal and external stakeholders, and the impact on corporate image/brand equity (Whiting, 2003). Also included are costs associated with changes in product quality as a result of regulatory changes that affect material inputs, methods of production, or allowable emissions (Gale & Stokoe, 2001). Contingent costs are difficult to estimate since there is absolutely no way to accurately quantify the full financial impact of negative consumer perception beyond understanding that perception is a very important intangible that should never be taken for granted. There are models available that estimate the various expenses of a situation and

actuarial displays which will outline probabilities, however, the decision making power of the consumer is still ambiguous at best. However, the Vision 200's eco-friendliness would tend to attract customers who are more sensitive to the environment – thereby heightening the importance of consumer perception and the impact of contingent costs to VDS.

3.4.6 External Costs – Tier 5

External costs are the costs of environmental damage external to the firm. These costs can be “monetized” (i.e., their monetary equivalent values can be assessed) through the review of economic methods that deduce the highest price the corporation will pay either to avoid the detrimental costs, or the lowest compensation it is willing to accept if it cannot be avoided. The method used to internalize these external costs is known as externality costing. There are two main approaches to externality costing: 1) Damage cost approach – using the value of loss of use to estimate externality costs, and 2) Probability and historical cost approach – using the likelihood of scenario occurrence and estimate the financial effect through historical happenings (Gale & Stokoe, 2001).

External Environmental Costs	
Examples: Depletion of natural resources Noise and aesthetic impacts Residual air and water emissions Long-term waste disposal Uncompensated health effects Change in local quality of life	
Internal Environmental Costs	
Direct or Indirect Environmental Costs	Contingent or Intangible Environmental Costs
<i>Examples:</i> <ul style="list-style-type: none"> • Waste management • Remediation costs or obligations • Compliance costs • Permit fees • Environmental training • Environmentally driven R&D • Environmentally related maintenance • Legal costs and fines • Environmental assurance bonds • Environmental certification/labeling • Natural resource inputs • Record keeping and reporting 	<i>Examples:</i> <ul style="list-style-type: none"> • Uncertain future remediation or compensation costs • Risk posed by future regulatory changes • Product quality • Employee health and satisfaction • Environmental knowledge assets • Sustainability of raw material inputs • Risk of impaired assets • Public/customer perception <p style="text-align: right;">Source: Gale & Stokoe, 2001</p>

Table 1: ECA cost segmentation

“From the perspective of society as a whole, economic efficiency is achieved (i.e. full environmental costs are minimized) when the firm takes internal measures to protect the environment up to the point where the sum of internal and external costs are minimized.” (Gale & Stokoe, 2001). At the conclusion of the calculations, the decision process is a very simple economic query. Where is the equilibrium? Which path will encounter the least financial exposure? The significance of ECA is in the paradigmatic shift it brings in the perception of costs from a solely financial harm viewpoint – i.e. what is the probability of an accident occurring and how much is the traditional settlement amount – to a more holistic environmental

perspective. When \$10,000 fines are analyzed from a billion dollar corporate perspective, there is naturally little incentive to address the root causes. However, when incorporating the potential cost savings on a large scale, the financial impact is magnified significantly as outlined in the following examples.

3.5 Demonstration of Economic Feasibility of Green Investments using ECA

To evaluate the financial impact of green capital investments in the automotive manufacturing industry, we employ two specific examples taken from case studies presented to the US Environmental Protection Agency to demonstrate the significant value of Environmental Accounting on aiding corporate decision-making with regards to environmental investments (Graff, Reiskin, White, & Bidwell, 1998).

3.5.1 Review of the Environmental Cost Impact on a Large Automobile Manufacturer

An unnamed automotive manufacturer with revenues in excess of \$10 billion and operating over 100 facilities worldwide, was concerned about the liabilities involved in the use of transformers containing carcinogenic Polychlorinated Biphenyls (PCBs) in the event of substance release through spillage or fire. The question before them was whether or not to allow these PCB-containing transformers to live out their 30-year life cycle, or to implement a plan that would see them phased-out over five years. We assume that the cost to phase-out the transformers would be equal to \$20,000,000. Thus in five years, the manufacturer would no longer have the liability of maintaining these PCB-containing transformers. The company would perceive the \$20,000,000 phase-out cost as an expensive proposition if the environmental accounting costs were not broken down effectively to reveal the full potential cost of doing nothing. In this example, no estimate for regulatory penalties or costs as a result of a diminished corporate image was

included to keep the computation simple. Instead, only those costs associated with clean-up, litigation and lost production (resulting from transformer fire or spill) were considered, since these represent the “low hanging fruit” of identifiable expenditures. Using the minimal probabilities (set by an actuary retained by the company) of .0034 for a spillage occurrence and .000018 for a fire, the environmental costs per transformer shown in Table 2 are obtained.

	Spill	Fire
Clean-up	\$ 339	\$ 140
Litigation	\$ 3,213	\$ 68
Lost Production	\$ 1,560	\$ 10
Total Costs (per transformer)	\$ 5,112	\$ 218
Number of transformers	5000	5000
Total Costs	\$ 25,560,000	\$ 1,090,000
Number of transformers	10,000	10,000
Total Costs	\$ 51,120,000	\$ 2,180,000
Number of transformers	20,000	20,000
Total Costs	\$ 102,240,000	\$ 4,360,000

Source: Tellus Institute - 1995 - Thesis Team Estimates

Table 2: Contingent costs per transformer incident

Traditionally, these costs would be generalized as “litigation costs” or possibly even typical “Selling, General and Advertisement” (SG&A) expenses involving general clean-ups/maintenance or production slowdowns. However, when aggregated as contingent costs, they amount to several millions of dollars as shown in Table 2. Assuming that only 5,000 transformer spills/leakages occur over the course of 30 years (a conservative number), the total potential liability is in excess of \$25,000,000 (using present day dollar values, before accounting for inflation and before factoring impact to corporate image and legal penalties). While \$25 million

in potential liability may not seem significant to a company with \$10 billion in revenues, it should be noted that this amount is only for PCB transformers in service and does not include PCB capacitors. Moreover, it does not factor any allowance for maintenance expenses or lower costs resulting from an alternative, environmentally-friendly solution (since special training and protective equipment must be provided for dealing with PCB transformers).

The simple example above illustrates how easy it is for companies to overlook the financial penalties of failing to factor environmental considerations into supply chain capital investment decisions. The requirements of running a green business model / green supply chain would compel VDS to consider issues like the above in its sourcing/procurement activities, which when combined with ECA, will help it to avoid wasteful contingent costs.

3.5.2 Review of the Environmental Cost Impact on Chrysler Corporation

This second case analyzes Chrysler Corporation's use of ECA for product design decision-making. In 1997, Chrysler faced a decision on the development of an automobile under-hood lighting package using a mercury switch or non-mercury alternative. Since mercury switches were priced at one-third to one-half of the cost of the non-mercury option, conventional business sense dictated that mercury switches should be used for the lighting package. The cost differential between mercury and non-mercury switches was approximately \$0.12 per switch (Chrysler Corp Life Cycle Programs, 1997).

However, Chrysler decided to undertake a Life Cycle Management (LCM) study on the lighting package, inclusive of environmental impact obligations, and analyzed the total costs involved. LCM analysis is a technique of ECA that is based on the fact that the costs accrued by a product during its lifecycle also affect the company's business costs. LCM incorporates variables based on health, safety, environmental impact and compliance requirements, and quantifies the effects

of each throughout the product's life. In the case of the mercury switch, several cost considerations were evaluated, namely: tooling costs, component weight effects, content of substances of concern, insurance premiums, environmental training, add-on environmental controls, end-of-life disposal, disassembly ratings, recycling costs, long term liability and atmospheric emissions. For example, in terms of add-on environmental costs, when a mercury switch is installed into a vehicle, US EPA regulations require automotive manufacturers to place special labels identifying the item as containing a material that is harmful to the environment. Similarly, for end-of-life disposal costs, the State of Minnesota has a statute prohibiting the crushing of motor vehicles without the prior removal of all mercury switches by the vehicle's manufacturer (This particular item would most certainly fall into a miscellaneous category on the income statement as the cost on a quarterly basis would be quite small). Lastly, countries like Sweden had actually banned mercury from all vehicles sold in the country, effectively closing that market to Chrysler.

The results of Chrysler's study revealed that the total environmental costs of the mercury switch over its lifecycle amounted to \$0.24 per switch (Yester, 2008). Thus, factoring the initial \$0.12 additional cost of the non-mercury alternative, the green solution would actually result in savings of \$0.12 per switch for Chrysler. Assuming one switch per car, implementing the non-mercury switch in all of the 2.5 million cars produced by Chrysler in 1997 would result in annual savings of over \$305,000 for the company. Factoring a 10% volume purchase discount and growth in vehicle production, the annual savings would be even larger. Also, this is without even considering the more significant profitability effects of access to otherwise closed markets like Sweden. Table 3 shows the ECA-based cost analysis calculations involved.

Lifetime cost savings per non-mercury switch	\$ 0.12
Total Chrysler Vehicle Production in 2006	<u>2,544,590</u>
Total Annual Cost Savings	\$ 305,351
Assume a 10% volume purchasing discount adds \$0.012 to savings per switch	\$ 0.132
Total Annual Savings	\$ 335,886
Total Savings over 5 years	\$ 1,679,429
Total Savings over 10 years	\$ 3,358,859
Total Savings over 15 years	\$ 5,038,288
Source: Chrysler, Wikipedia, Research Team Estimates	

Table 3: Cost analysis between mercury and non-mercury alternative

The impact of \$335,886 in annual savings might seem insignificant to a multi-billion-dollar organization when considered in isolation. However, large automotive manufacturers like Chrysler have over 160,000 SKUs in its supply chain, and each car has approximately 20,000 SKUs. Assuming just two SKUs in each car (i.e. 0.01% of an average car's total SKUs) yielded the same amount of savings as in this example, the magnitude of the savings quickly become apparent. For example, if Chrysler identifies savings of equal amount as the switch in this example for just 0.1% of the total number of SKUs utilized in the production of an automobile (Assuming 20,000 SKUs, 0.1% would equal 20 SKUs), the savings to the corporation would be in excess of \$100 million over fifteen years, without adjusting for inflation. Although smaller companies like VDS may not have the scale to reap cost savings of such magnitude, the relative cost savings per car resulting from concurrent product engineering and supply chain design, like up-front investment in green components and manufacturing, would still result in significant downstream financial benefits. This is especially if VDS opts for thinner profit margins than their competitors as a market-entry strategy.

3.6 Summary

This chapter highlighted facility location, supply chain network design and manufacturing capital investment as the key factors impacting the economics of establishing a green supply chain in India. Environmental Cost Accounting was introduced as the management decision tool to use in determining the financial feasibility of investments in green solutions like use of environmentally-friendly parts in component design, or investment in green manufacturing capital. Two case studies from the automotive industry were presented to show that: 1) Green solutions, while seemingly more expensive due to their higher up-front cost, often yielded significant cost savings for the firm over the product's lifecycle, 2) ECA is an important management decision tool for deciding the feasibility of green investments based on their projected financial benefits.

While the anecdotal evidence points strongly to the economic viability of running a green automotive supply chain in India, VDS' management must diligently utilize ECA to evaluate the financial and environmental viability of product design and component sourcing decisions for the Vision 200, since these will impact manufacturing capital expenditure (in terms of what equipment to procure) and the supply chain network design (due to which suppliers are selected). The next chapter identifies the critical supply chain functions VDS should focus on to not only optimize its financial benefits, but also to provide the foundation for the solutions that will characterize its supply chain as a truly green one.

Chapter 4 Hypothetical VDS Supply Chain

To develop a hypothetical supply chain for VDS, examples from two major automotive companies – Toyota Motors and General Motors – were studied to identify existing best practices to build upon. Toyota was selected as it is the industry leader in lean automotive supply chains, while GM was selected for its strong track record of success in establishing automotive supply chains within emerging markets like China and India.

4.1 Review of the General Motors Supply Chain

GM produces in over 87 countries and 200 manufacturing locations, making it the world's largest automobile manufacturer. The supply chain for GM covers over 160,000 SKUs across its entire automotive line with an annual logistics budget of \$7.2 billion, and \$89 billion in parts purchased across the globe. GM has an average of 600 Tier 1 suppliers worldwide, all of which are ISO14001-certified as of 2006.

4.1.1 GM's Supply Chain Strategy

The GM supply chain revolves around four primary functions: 1) sourcing/purchase of raw materials and components, 2) transportation of raw materials and components to the manufacturing/assembly facility, 3) manufacturing/assembly, and 4) distribution of the finished goods to the sales locations.

Because of the diverse markets served, a key strategy of GM's supply chain is the reduction of costs through local sourcing. Local sourcing allows GM to take advantage of the lower wages in emerging economies by locating assembly facilities in those markets. For example, the wage expenses incurred by GM for production in emerging markets, like China and India, is only

\$1.70 per worker per hour on average – significantly less than that for countries using a union-based wage structure like the United States.

Further, in the early 1990s, GM focused on cost reductions in attempting to stay competitive against the Japanese automotive companies. This was mainly through increasing the efficiency of its supply chain by adopting lean techniques (Howell, 2003, and Braesi 2005). GM next focused on optimizing the high fixed costs of its operations, including capital investment for the lean production technologies, through increasing economies of scale to achieve maximum utilization of their assets. This, however, impeded operational flexibility (Shilling, 2005, and Braesi, 2005). These lessons were applied when GM expanded its operations in emerging economies, and local sourcing was a key element of retaining operational flexibility, avoiding high fixed costs, and reducing transportation costs.

The local sourcing strategy extends even to the procurement of key components like engines, where possible. For example, the automotive supply chain landscape is surprisingly fraternal. It is not uncommon to have one company purchase an entire engine for one of its automobiles from another company – as GM has done with Honda in India. This simplifies GM's supply chain in several ways: What would normally be a relationship with 20 suppliers for engine parts has been consolidated into one. The labor hours of assembling the finished part have been consolidated into those required to receive the engine at the assembly plant. Although there is a margin placed on having a 'middle man' (in this case, Honda) oversee the production of such a substantial piece of the vehicle, these are more than offset by the savings in labor, fixed investments and administrative costs. Moreover, the long supplier-OEM relationship between Honda and GM also plays a part in making engine procurement more worthwhile than in-house production, at least in emerging markets.

4.2 Supplier Selection at General Motors

The four criteria utilized by GM's Global Purchasing Organization (GPO) to select suppliers are centered on the JIT (Just-In-Time) philosophy of its GM supply chain:

1. *Service – Delivery must be in a timely fashion*
2. *Quality – The part must meet specifications; non-conformance will impact JIT production schedules*
3. *Technology – Supplier facilities and resources directly support points 1 & 2*
4. *Price – Lean production incorporates procurement selections that are cost effective*

The above four criteria bears out the importance of supplier reliability to GM – variability in lead times for delivery must be kept at a minimum; the quality and technology aspects of the chain are necessary for the components to meet with GM's specifications with regard to parts engineering so as to minimize rework and facilitate JIT production. Finally, price is a key factor for maintaining a lean operation, but not at the expense of unsustainable supplier relationships.

Once the GPO has conducted its analysis and identified a potential supplier, the supply chain, engineering and quality control departments must agree that this particular supplier represents the best possible available for manufacturing and delivering the specified part. Unless agreement is unanimous, another supplier must be chosen (Braesi, 2005).

4.2.1 Best Practices for VDS

The following best practices from GM's supply chain were identified as relevant for VDS to incorporate into its own supply chain for the Indian emerging market:

1. Use of local sourcing. Where possible, VDS should source/procure all raw materials and components locally from Indian suppliers. This allows for transportation, labor and

administrative costs to be minimized, and for avoidance of high fixed costs from establishing in-house production facilities. This is especially important given that the projected production volume for the Vision 200 (at least initially) would not yield economies of scale. Apart from cost savings, local sourcing also confers the key benefit of operational flexibility. This is essential for a small industry player like VDS to compete in the higher clockspeed niche of small, eco-friendly cars. As product styles and technologies are likely to evolve faster in this car segment, VDS must adopt supply chain practices that help it to stay nimble.

2. Supplier selection criteria. The use of local sourcing will require robust supplier selection criteria. While GM's emphasis on supplier reliability, in terms of meeting its JIT production targets, would be beneficial for reducing on-hand parts inventory costs, VDS should focus more on reliability of quality to avoid costly rework. This is because JIT production may not confer the same amount of advantage to VDS given its limited production volume and niche market.

4.3 Review of the Toyota Motors Supply Chain

Toyota pioneered the concept of the lean supply chain, which evolved as a direct result of the Toyota Production System (i.e. lean production). The basic structure of Toyota's supply chain is similar to GM's, not only because both are in the same industry, but also because GM – and other Western automotive manufacturers – modeled much of their supply chains on Toyota's lean system.

4.3.1 Toyota's Supply Chain Strategy

Toyota's supply chain philosophy revolves around establishing close and mutually-beneficial relationships with their suppliers. Toyota believes that it is only through the strength and trust of this relationship that lower costs, delivery reliability and quality of the product can be achieved.

In developing a supply chain for a new market, Toyota's strategy calls for a 36-month planning process prior to production and a bidding process to consider new suppliers. During this time, an infrastructure is designed within the supplier country to ensure that the delivery requirements can be met. Engineers also create a series of product specifications that optimize the strengths of the particular supplier candidates, and improve elements of the initial design. Toyota believes that it is critical to understand the market to maximize its potential. Thus, it is willing to undertake multiple changes to the original product design. These adaptations are managed in an "open book" policy, in line with Toyota's belief that all aspects of the supply chain must be visible. Profit margins on the various components are contractually limited, which helps Toyota manage its costs. In the supply contracts, each party's responsibilities are clearly spelled out so as to eliminate any potential misunderstanding. If Toyota alters a specification on a component, reasonable price changes will be agreed with the supplier. In the event of a disparity between the supplier's claims and Toyota's estimate, then Toyota will audit the component production process to confirm the actual cost.

Toyota utilizes suppliers from around the world to benchmark its procurement costs and to monitor margin inflation by suppliers. Although there are penalty clauses in its contracts to dissuade suppliers from inflating margins, Toyota rarely resorts to punitive measures, preferring instead to resolve such situations amicably through discussion so as to preserve the working relationship with its suppliers.

4.3.2 Toyota Supplier Relations

To build and maintain strong team relationships with its Tier 1 suppliers, Toyota second its key staff to work in the suppliers' organizations every two to three years. Suppliers also reciprocate by deploying their staff to work alongside Toyota engineers in designing the supplied

components and matching it to Toyota's supply chain requirements. Supplier involvement in component design is a key aspect of Toyota's philosophy on Value Engineering – for example, the production of one component to accomplish two tasks rather than producing multiple components. Costs and specifications are analyzed prior to initiating the supply chain process and required changes are made before tooling takes place.

Such close teamwork fosters a deep sense of trust amongst suppliers that Toyota is concerned about the problems they face, and will exhibit as much empathy as possible. Indeed, Toyota suppliers have come to trust its dispute resolution panel to be consistent and fair in its rulings on supply chain issues. This encourages suppliers to share obstacles faced in the production process, giving Toyota early warning of potential problems. Recognizing that early rectification of problems can save much more in downstream costs, Toyota rewards suppliers' transparency and forthrightness by sharing in the rectification costs involved if the issue was brought to Toyota immediately.

So prevalent is this team approach that Toyota will invest in educating their suppliers on the latest techniques and business knowledge. These investments are undertaken to equip suppliers with the skills to fulfill their roles for the lifetime of a particular car model, typically 5 years.

4.3.3 Supplier Selection at Toyota

All current suppliers have the ability to present a proposal for new business at model changes. The key criterion is that Toyota must feel confident that the bid is realistic and can be sustained. Toyota will make an onsite visit with a team that includes a Quality Engineer, Production Tooling Engineer and Logistics Specialist. Each system is analyzed from the point that raw materials are brought in to its finished state. They then analyze the system in what is referred to as a "Traffic Light" evaluation, which has three levels:

- Acceptable – invited to bid
- Some concern – invited to bid, but possible issues are listed out
- Unacceptable – not invited to bid

At the pre-sourcing meeting, various scenarios are discussed which help Toyota to understand the supplier's company culture. If there is a strong dichotomy between Toyota's culture and that of the supplier's, the relationship will not be pursued.

These extensive evaluations are common and considered part of the typical overhead incurred in the supply chain line items on the company's income statements. This overhead is then taken into consideration when Toyota sets a target price and profit when creating a new vehicle.

Central to the supplier's bid are the potential savings from the value engineering process described earlier. The value of the supplier's VE ideas is quantified based on the projected savings and deducted from the supplier's bid price – in effect reflecting Toyota's expectation of the supplier's contribution to its production cost savings.

4.3.4 Dealer and Customer Relations at Toyota

Toyota views its dealers and end-customers – the car buyers – as part of the Toyota family. It believes that customers close the supply chain loop by providing information on the type of cars they want Toyota to produce. Toyota dealers play an important role in this process by constantly collecting feedback on product performance as well as changes in customer lifestyle preferences to aid the design process for the next generation of models (Womack, Jones, & Roos, 2007).

4.3.5 Best Practices for VDS

In addition to the general lean supply chain principles, the following best practices from Toyota's supply chain were identified as useful for VDS to adopt:

1. Supplier relations management. Toyota's trust- and teamwork-based supplier relations management framework is useful for identifying and resolving supply chain problems early. Mutual trust also facilitates greater cost transparency across the supply chain, making it easier for VDS to continually improve its cost performance.
2. Supplier contribution to Value Engineering. Involving suppliers early in the component design process and incentivizing them to contribute ideas for process and product improvements via contract bid preferencing, is an integral strategy for lean supply chain management.
3. Dealer and Customer management. VDS can reap 'clockspeed advantages' by designing cars to the requirements of customers. Being small, it is able to offer a greater degree of product customization than the larger automotive manufacturers with less flexible production processes. VDS must harness its dealers as not only a channel of sales but also a source of information on customer preferences.

4.4 Structure of Hypothetical VDS Supply Chain

It has been suggested that the ultimate core competency of an organization is supply chain design – defined as choosing which value chain capabilities to invest in and which to outsource to suppliers (Fine, 1998). This is especially true for high clockspeed industries (i.e. industries with rapid rates of evolution), like the computer industry, as they require lean and flexible supply chains to survive, let alone turn a profit. The automobile industry is very much a high clockspeed industry too, with lean manufacturers like Toyota able to bring a new model from the drawing board to first article production in little over a year.

Competing in the new high-technology 'eco-car' niche, VDS may be shielded somewhat from the pace of the conventional passenger car industry, but the advantage may not last long as

additional players will enter its niche market and increase the clockspeed through competitive action encouraging faster introduction of new models. Thus, the fundamental challenges in designing VDS' supply chain are to ensure: 1) astute selection of the value chain activities to invest in and develop internally, 2) careful selection of suppliers to undertake the remaining supply chain activities, and 3) achieve supplier flexibility without undermining the long-term partnerships essential for lean and green supply chain management.

Considering its industry, product, organizational composition and size, and business environment, VDS' competitive advantage lies in its *design competence*. Thus, supply chain activities directly related to transforming its vehicle designs into reality – such as manufacturing and assembly – should be invested and developed internally. Because of the importance of supplier selection, the sourcing/procurement function should also be internal to ensure product quality and supply chain reliability. Supporting functions such as transportation and sales should be allocated to 3rd-party service providers.

Based on the lessons from GM and Toyota, VDS' hypothetical supply chain will have the following characteristics:

1. Consist of the main functions of sourcing/procurement, transportation, manufacturing/assembly, distribution/sales
2. Feature local sourcing to minimize costs and leverage economies of scale from large Tier 1 suppliers
3. Incorporate stringent supplier selection criteria focused on product quality and delivery reliability
4. Foster close supplier relations built on mutual trust and teamwork, value engineering principles, and total visibility of supply chain costs

5. Centrally-coordinated by VDS management to achieve a seamless, uniform picture of all supply chain activities and to allow synchronized responses problems

As mentioned in Chapter 1, because the configuration of the Vision 200 is not yet finalized, it is impossible to base treatment of the VDS supply chain on a parts basis (i.e. using a physical perspective). Hence, the hypothetical supply chain will be designed based on a functional perspective (as discussed in section 1.2.1), with the key activities VDS should develop internally or allocate to suppliers/service providers specified. However, it should be noted that during the present product development and prototyping phase, the 5 groups of international VDS technical teams (Body, Electrical, HMI, Chassis and Propulsion) have self-organized a de-centralized ‘supply chain’ to obtain the parts required for their respective sub-system development efforts. This informal supply chain is optimized for the current stage of development for the Vision 200 project, but not for lean manufacturing because its structure does not provide chain-wide visibility nor facilitate ease of coordination across the component classes.

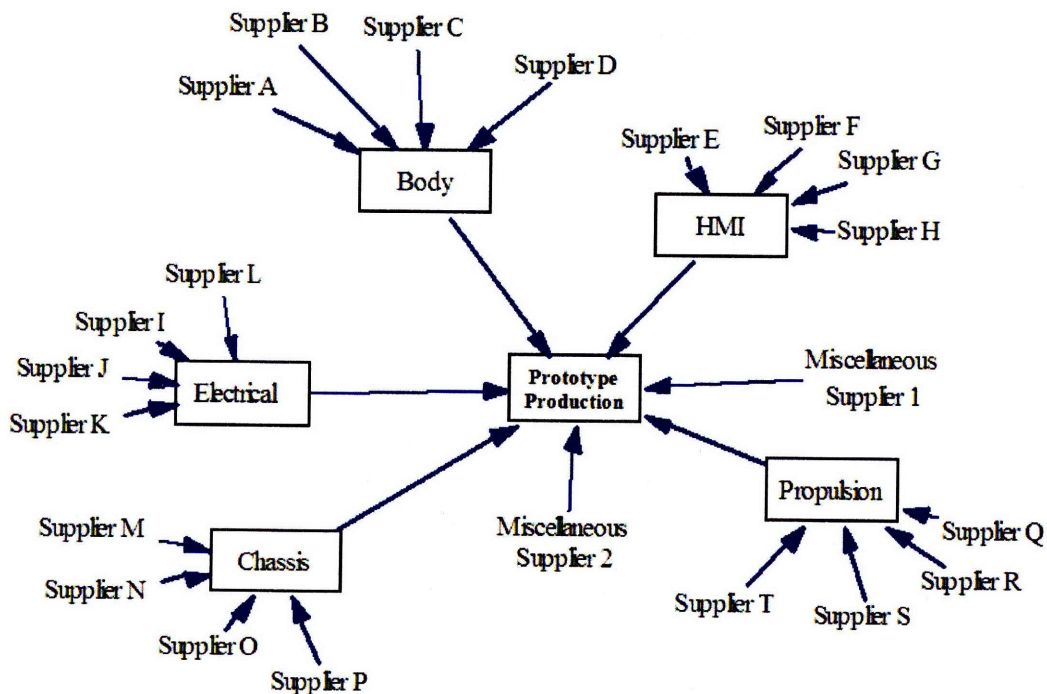
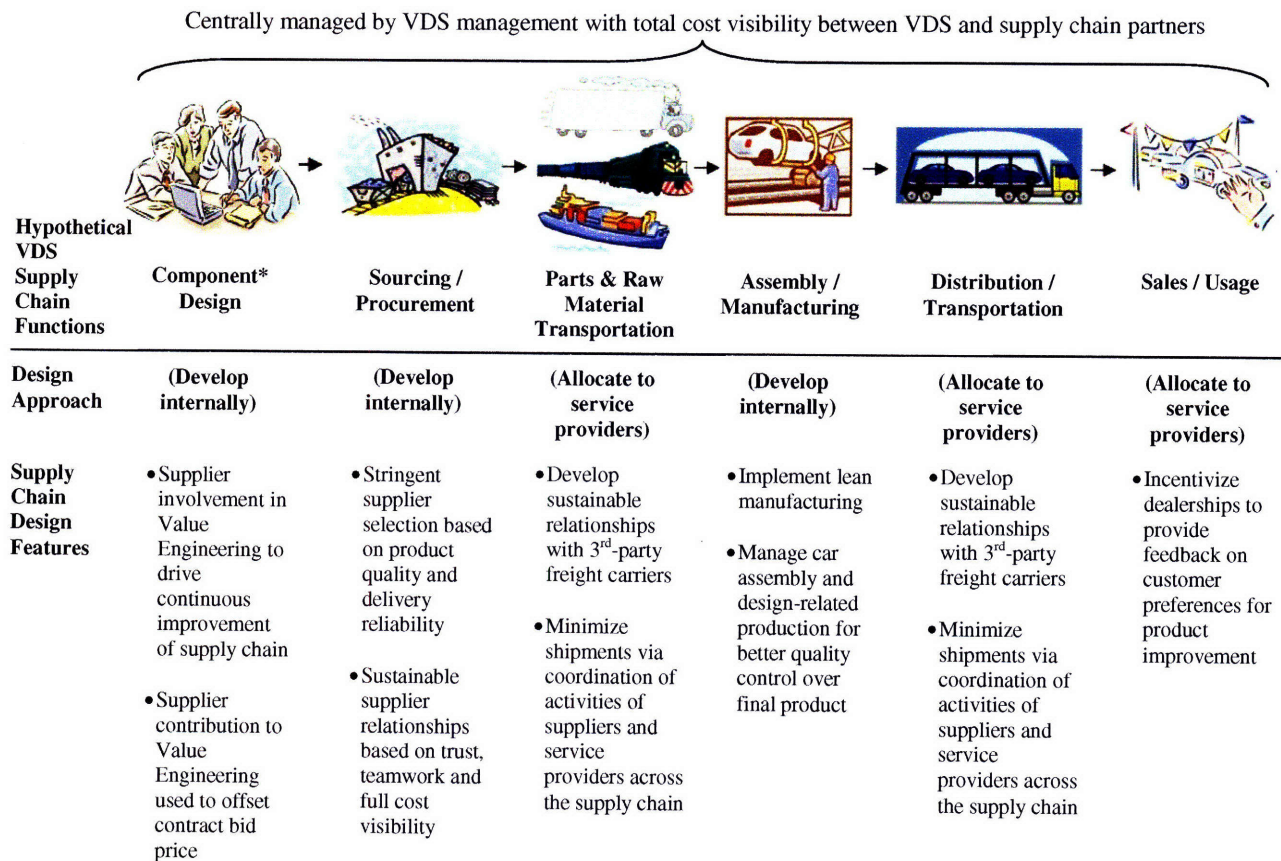


Figure 6: Informal self-organized supply chain for Vision 200 development phase

However, the relationships forged by the technical teams with their suppliers could be cultivated further if it is determined through the supplier selection process that they are suitable partners for VDS' lean supply chain. In any case, suppliers for the prototype development would be given priority since they would already possess knowledge of the components required.

Thus, the hypothetical lean supply chain for VDS must be centrally coordinated by management to ensure optimization. The following diagram depicts the proposed hypothetical VDS supply chain based on best practices from Toyota and GM, and considering the emerging market business context of VDS.



*Component Design is not, strictly speaking, a supply chain function. Instead, it is a product development function. However, it is included here because of the advocated supplier involvement in the Value Engineering process, which has a direct effect on the sourcing/procurement function of the hypothetical supply chain.

Figure 7: Hypothetical VDS supply chain

4.5 Summary

Using a functional perspective, this chapter proposed a hypothetical VDS supply chain based on combining best practices from the supply chains of GM and Toyota, as well as from considering VDS' own requirements due to its unique operating context as a start-up automotive manufacturer in India. The three fundamental challenges in designing VDS' supply chain are: 1) astute selection of the value chain activities to invest in and develop internally, 2) careful selection of suppliers to undertake the remaining supply chain activities, and 3) achieve supplier flexibility without undermining the long-term partnerships essential for lean and green supply chain management. The key consideration is how the supply chain supports lean manufacturing, which is the cornerstone of the VDS green supply chain strategy.

Chapter 5 Green Solutions for the VDS Supply Chain

To develop solutions for greening the hypothetical VDS supply chain, it is first necessary to examine the activities in each of the supply chain's four functions of Sourcing/Procurement, Manufacturing, Distribution/Transport and Product Recovery. Next, the associated sources of pollution must be identified and appropriate countermeasures proposed. The following sections discuss the anticipated activities in each function of VDS' supply chain based on its business context, and describe the proposed green solutions for each.

5.1 Sourcing/Procurement

5.1.1 Description of Activities

The supply chain function of Sourcing/Procurement within the VDS business context involves the following activities:

1. Purchase of key automotive components by VDS from overseas and local Tier 1 suppliers. For example, purchase of the Vision 200 engine by VDS from an engine manufacturer like Honda.
2. Purchase of raw materials or sub-components by Tier 1 suppliers from lower tier suppliers. For example, purchase of sheet metal for the engine by Honda from a steel producer like ArcelorMittal.
3. Extraction of raw materials from the Earth by raw material suppliers. For example, extraction of iron ore from the Earth by a raw material supplier like ArcelorMittal for steel production.

Critical components like the engine and transmission for the Vision 200 are likely to be purchased from major Tier 1 suppliers in the automotive industry due to the following reasons:

1. Advanced technology required to manufacture these components
2. Availability of after sales spares and technical support for end consumers

However, less sophisticated components like the tires, wheels and headlights, and consumables like fasteners (e.g. nuts and bolts) should be purchased from local Tier 1 suppliers as they are likely to be cheaper than imported equivalents.

5.1.2 Sources of Pollution

At the heart of green sourcing/procurement is the environmental credibility of the suppliers to VDS. The key source of *direct* pollution within this supply chain function is therefore the activities of Tier 1 suppliers who: 1) Have inefficient production processes that generate large amounts of waste, and 2) Do not have proper environmental management processes to control pollution resulting from their operations.

The other source of pollution within this function stems from the suppliers' supply chains. That is, VDS' *extended* supply chain. Unless VDS' suppliers share the same practice of sourcing/procuring from green suppliers, the environmentally-adverse practices of upstream suppliers will be a source of *indirect* pollution to all downstream sourcing/procurement in the supply chain.

5.1.3 Green Solution for Sourcing/Procurement

Thus, greening of the sourcing/procurement function involves ensuring that all of VDS' suppliers have the same commitment to environmental protection as VDS itself. At the most

stringent level, this can be achieved by selecting only suppliers with proven environmental credentials like a green supply chain. Obviously, if all of VDS' suppliers had green supply chains of their own, then VDS' entire upstream supply chain would also be green! However, the state of green supply chain development within the automotive industry is not sufficiently mature for VDS to have the luxury of selecting only suppliers with green supply chains – especially in emerging economies like India.

So realistically, VDS can only select suppliers based on criteria like possession of environmental credentials such as an ISO14001-accredited EMS⁵. But having an ISO14001-accredited EMS alone does not mean that the supplier is actually green since this depends very much upon how well the EMS is implemented. Studies have shown that companies practicing lean production are greener and have superior EMS implementation. In fact, it is often the case that lean production forms the basis for an effective EMS, giving rise to the idea of *Lean and Clean*. Hence, the real solution to green sourcing/procurement is to engage suppliers practicing lean production.

As described in section 5.1.1, VDS will need to forge partnerships with two types of Tier 1 suppliers: 1) Large, multinational overseas suppliers for critical advanced-technology components like the engine and transmission, and 2) Smaller, local suppliers for consumables and the remaining parts that VDS will not manufacture itself.

The first type of Tier 1 supplier (i.e. large multinational like Honda) is likely to be a lean producer, and may even have its own green supply chain. Hence, VDS can be reasonably assured

⁵ Given the widespread adoption of ISO14001 as the international standard for proving environmental commitment, this is very likely the only criteria available anyway.

of the 'green pedigree' of the components it procures from such a Tier 1 supplier. As a customer, VDS can request for annual EMS re-certification reports from these suppliers to satisfy itself of the supplier's continued commitment to good environmental management practices.

The second type of Tier 1 supplier (i.e. small, local supplier) needs to be assisted to adopt relevant lean production techniques, and to develop and implement an EMS based on an international standard like the ISO14001, if it does not already have one. Agreement to commit to green practices via a lean production-based EMS must be the pre-requisite for VDS to engage such Tier 1 suppliers. However, because of the enormous effort required, VDS cannot afford to divert its resources to helping all such potential Tier 1 suppliers. Instead, it should only make available its own best practices in lean production and EMS implementation by playing the role of a corporate 'mentor' to these suppliers.

5.1.4 The Green Suppliers Network

To help small- and medium-sized companies like VDS engage their suppliers in lean and green practices, the US Environmental Protection Agency (EPA), in collaboration with the US Department of Commerce (DoC), established the Green Suppliers Network (GSN). The GSN provides a good framework for automotive manufacturers to directly engage their extended supplier network on green practices by becoming a Corporate Champion and getting their suppliers to join as Partners, at a nominal fee. It is premised on using lean production principles to achieve clean production by reducing wastes. By joining, suppliers commit to participating in a low-cost '*Lean and Clean Technical Review*'. The GSN Technical Review team works with the Corporate Champions to help their suppliers identify strategies for improving process lines and using materials more efficiently via *value stream mapping*. Value stream mapping is a process-

mapping technique that tracks inputs and outputs through either an individual process or complete product line. It serves as a critical tool during the review process and can reveal substantial opportunities to reduce costs, enhance production flow, save time, reduce inventory, and improve environmental performance. Typical mapping exercises begin by looking at the facility-wide level as it tracks product movement through the individual processes. Once opportunities for improvement are recognized, the mapping exercise focuses on the specific details of a manufacturing process in order to target and eliminate the root causes of waste, resulting in both financial and green benefits (Green Suppliers Network, 2007). The EPA is not involved in any onsite technical assistance.

Through participation as a Corporate Champion, VDS can expect the following benefits:-

1. Strengthening of its supply chain. Through the customized, onsite Technical Reviews that identify strategies for improving process lines and using materials more efficiently (i.e. go *lean*), Partners will be able to improve the overall quality, delivery, and cost of products supplied to VDS.
2. Greening of its supply chain. The Technical Reviews also help VDS' suppliers identify non-value added inputs in their manufacturing processes that result in: 1) Hazardous waste, 2) Emissions to air and water, 3) Wasted energy and 4) Scrap and rework. As suppliers implement recommendations from the GSN reviews to go *clean*, they become more material and energy efficient, thereby reducing the environmental footprint of VDS' supply chain.
3. Learning about its own supply chain environmental performance. Through its suppliers' Technical Review results, VDS will discover more about its true environmental footprint by

receiving aggregate information about the environmental performance of its *extended* supply chain. This will help VDS to cascade Lean and Clean best practices beyond Tier 1 to its lower tier suppliers, whilst gaining insight into their operations.

Although partnership in the GSN is presently restricted to US-based suppliers, VDS should still join as a Corporate Champion to gain access to the framework tools and industry best practices which it can share with its non-US suppliers. Just as important, experience and learning derived from being a GSN Corporate Champion will also help VDS to fine-tune its own lean production methods, which is key to greening its manufacturing as described in the next section.

5.2 Manufacturing

5.2.1 Description of Activities

As the OEM, VDS will need to perform the final assembly of the Vision 200 using components purchased from Tier 1 suppliers (like those described in the previous section), and some of its own manufactured components. The components VDS will manufacture itself are those that are unique to the Vision 200, including the chassis frame, door frames and other body panels like the roof, floorboard and hood. Refer to diagram of key components of a car (the Smart Tridion) shown below. This car is similar to the VDS Vision 200 in size and weight class.

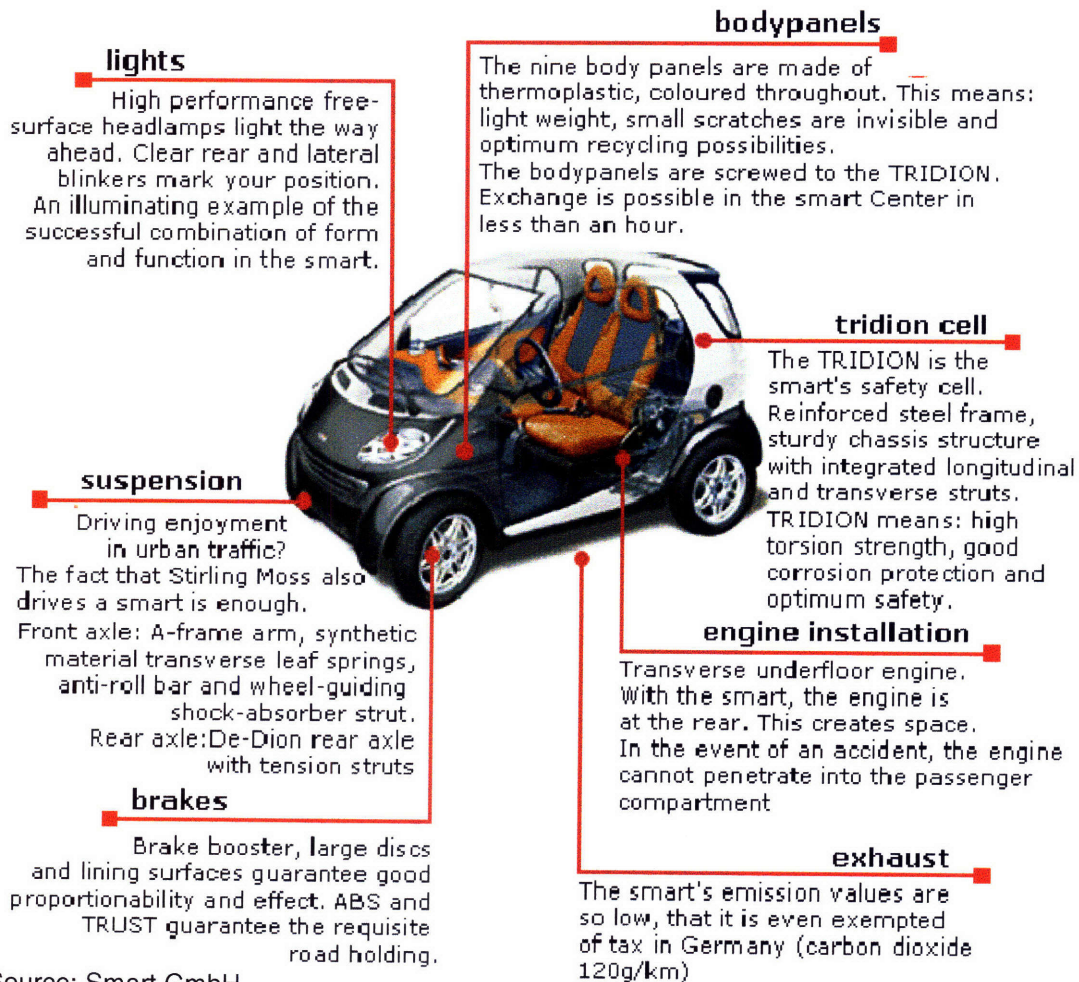


Figure 8: Key components of a car in the same size and weight class as the VDS Vision 200

Because the chassis frame is the vehicle's main load-bearing member and source of structural rigidity, it has to be fabricated from stamped metal parts welded together. As for the non-structural members like the doors, roof, floorboard and hood, VDS has not decided if these will be made of metal or carbon-fiber.

5.2.2 Sources of Pollution

Obviously, these different materials require different manufacturing processes, resulting in different potential forms of pollution. For example, the epoxy resins used to impregnate the layers of carbon-fiber fabric in the production process (called 'wet lay-up') for carbon-fiber parts

are toxic, and the fumes emitted during the baking (called autoclaving) or thermoforming process to cure the resins must be treated before release into the atmosphere. Likewise, the industrial lubricants and coolants used in the metal cutting and stamping process require proper collection and disposal by specialized industrial waste treatment contractors. The same applies to the chemicals used to clean, roughen and prime the vehicle bodies for spray painting (e.g. the phosphate and electrophoretic baths), which is another key source of pollution in vehicle manufacturing. Given the small annual production capacity of 5000 units, VDS is likely to have a single assembly/manufacturing facility in India. Thus, although there may be many different types and sources of pollution within the Manufacturing function of VDS' supply chain (depending on the actual manufacturing processes involved in the Vision 200's production), any potential pollution effects can be addressed under the EMS for VDS' assembly/manufacturing facility.

This assembly/manufacturing facility is also likely to be VDS' largest infrastructure investment, and its upkeep will be a key source of recurring costs. If not properly designed, the facility (probably comprising office and warehousing space as well) will consume more resources like electricity and water than necessary. It may also generate pollution during its construction, through use of environmentally-unfriendly materials and poor management of construction wastes. Thus, the facility has the potential to be a source of pollution both during its operation and construction phases if no attention is paid to its design.

5.2.3 Green Solution for Manufacturing

Much has already been presented about the lean and clean benefits of lean automotive production. In fact, lean production along the lines of the Toyota Production System or its

variations, has become the standard for clean production in the automotive industry because of the aggressive manner by which wastes of all types are identified and eliminated. The main issue concerning green manufacturing in the VDS supply chain, then, is not whether VDS should adopt lean production, but what is the best way to do so considering its available resources and production scale.

First, the knowledge of automotive lean production techniques relevant to VDS' manufacturing/assembly process must be obtained. This open-source information is easily available via a variety of sources from published literature to site visits to lean automotive production facilities like the NUMMI⁶ plant in California. Additionally, participation in programs like the Green Suppliers Network is perhaps the best way of keeping abreast with the latest in lean production best practices, and learning how to implement them from more established program members like General Motors. Apart from the in-depth Technical Reviews, the GSN also provides a wealth of 'Lean and Clean' management tools to Corporate Champions and their Partners, including tailored training programs for their staff. Thus, VDS should leverage the GSN's rich lean expertise to green both sourcing/procurement and manufacturing functions of its supply chain.

Apart from implementing lean production, the second issue is to address the sources of pollution described in the last section by implementing countermeasures based on international standards. For example, the surface treatment of metals and plastics is a key process in automotive manufacturing used to prepare these parts for follow-on activities like painting. Due to the toxic

⁶ The New United Motor Manufacturing, Inc. (NUMMI) is a joint venture between GM and Toyota established in 1984 to trial lean automotive production in the US.

chemicals involved in this process, the EU has promulgated a reference document on best available techniques to prevent pollution arising from it. Similar documents addressing pollution from metal fabrication, metal finishing and parts washing are also available from regulatory agencies like the EPA. Again, the GSN also provides material and training on best practices to control these sources of manufacturing pollution as part of the value stream mapping process.

5.2.4 Green Solution for Buildings & Facilities

In the US alone, buildings use one-third of the nation's total energy, two-thirds of its electricity, and one-eighth of its freshwater. Buildings also transform land that may play valuable roles in the ecology (US Green Building Council, 2005). To address the issue of pollution originating from the construction and operation of VDS' assembly/manufacturing facility, it is necessary to adopt a green approach to its design and construction.

Recognizing the need to provide guidelines for 'greening' buildings, the US Green Building Council promulgated the Leadership in Energy and Environmental Design (LEED) Green Building Rating System for New Construction in 1999. LEED has since become the nationally-recognized standard for green buildings, and it gives building owners and operators the tools they need to have an immediate and measurable impact on their buildings' performance. It promotes a whole-building approach to environmental performance through sustainable site development, water savings, energy efficiency, materials selection and indoor environmental quality. VDS should therefore utilize the Commercial Interiors version of the LEED Green Building Rating System for New Construction as a guide in designing its assembly/manufacturing facility to be a green building. This can be achieved by incorporating green features like use of natural lighting (i.e. skylights), collection and use of rain water, design

for ease of cleaning, selection of energy-efficient materials and appropriate site selection for ease of accessibility to promote the use of eco-friendly transportation by staff (e.g. public transport or bicycles etc.).

5.3 Distribution/Transport

5.3.1 Description of Activities

Although VDS has not decided on its sales model, the most common sales model used in the Indian automotive industry is the car dealership franchise model. The distribution function for a supply chain incorporating sales through franchised dealerships entails sending finished cars from the assembly/manufacturing plant to the dealerships for display and sale to end-consumers. The main activity within the distribution function is thus transportation of the new cars. New car inventory storage and management at the assembly/manufacturing plant, plus sales at the auto dealerships, comprise the other key activities.

5.3.2 Sources of Pollution

Thus, the main form of pollution stemming from Distribution/Transport is exhaust emissions (containing mainly volatile organic compounds, carbon monoxide, carbon dioxide and nitrogen oxide) from the vehicles used to transport components like engines from Tier 1 suppliers to the assembly plant, and the finished new cars from the assembly plant to the dealerships. The main modes for transporting these goods are truck and rail, though for components procured from overseas suppliers, container ships are also necessary. For each mode, there is also the possibility of environmental contamination from fuel, oil, lubricant or hydraulic fluid leakage from the transporters' mechanical systems.

Lastly, limited environmental impact may occur through new car inventory management activities like exterior cleaning and washing prior to sales resulting in some electricity and water consumption. Waste water from car washing activities at the dealerships should be properly channeled into the sewage system and not into storm drains that lead to rivers and lakes.

5.3.3 Green Solution for Distribution/Transport

The key to reducing pollution within the distribution/transport function is to reduce exhaust emissions from the transporters. This can be done by the following ways: 1) Utilization of the most fuel-efficient mode of transport per unit weight carried, 2) Improving the fuel efficiency of the selected mode of transport, 3) Minimizing the total engine running time by efficient route planning or reduction in engine idling time, and 4) Training transport operators to adopt fuel-efficient behavior like controlled acceleration and cruising at fuel-efficient speeds.

Aside from emission reduction, proper transportation equipment maintenance is essential for preventing pollution from fuel, oil and hydraulic fluid leakages into the environment. Catalytic converters must also be serviceable to ensure that toxic substances from fuel combustion are not released into the atmosphere.

Recognizing the need for a framework to holistically combine all of the above pollution control measures for the US ground transportation industry, the EPA initiated a transportation version of the GSN program called the SmartWay Transport Partnership, described in the next section.

5.3.4 SmartWay Transport Partnership

SmartWay Transport is a voluntary partnership between the U.S. Environmental Protection Agency (EPA) and members of the various freight industry sectors that establishes incentives for improvements in fuel efficiency and reductions in greenhouse gas emissions. The SmartWay

partnership aims to reduce 33 - 66 million metric tons of carbon dioxide (CO₂) emissions and up to 200,000 tons of nitrogen oxide (NO_x) emitted annually by the freight industry by 2012.

Simultaneously, the initiative will result in annual fuel savings of up to 150 million barrels of oil. The program consists of three primary components: 1) creating partnerships with industry players, 2) reducing unnecessary engine idling, and 3) increasing the efficiency and use of rail and intermodal operations.

Creating Partnerships

The foundation of the SmartWay Transport Program is based upon forging partnerships with: 1) Shippers (i.e. users of freight transportation services) and 2) Carriers (i.e. operators of truck and rail freight services). SmartWay partners commit to measure and improve the efficiency of their freight operations using EPA-developed tools that quantify the benefits of a number of fuel-saving strategies based on adopting improvements in:-

- i. Fuel-efficient technologies like hybrid power trains, low-viscosity lubricants, single wide-based tires, automatic tire inflation systems and aerodynamic trailer designs
- ii. Operations processes like engine idle time and highway speed reduction, driver training to maximize fuel economy and use of intermodal shipping where possible (i.e. freight trains for the long-haul and trucks for the final hub-to-spoke delivery). Intermodal freight transport combines the best attributes of both truck and rail shipping, and for long distances, can cut fuel use and greenhouse gas emissions by 65%, compared to truck-only moves.

To encourage the adoption of such fuel-saving technologies and processes, SmartWay works with states, banks, and other organizations to develop innovative financing options that help

partners purchase devices that save fuel and reduce emissions. This makes greening freight operations even more attractive to small- and medium-sized enterprises and start-ups like VDS.

Using the National Transportation Idle-Free Corridors

Another component of the SmartWay Transport Partnership is to eliminate unnecessary truck and rail idling by developing a nationwide network of idle-reduction options along major transportation corridors in the US – like truck stops, travel centers, distribution hubs, rail switch yards, borders, ports, and even along the side of the road. As VDS is likely to still procure key components for the Vision 200, such as the powertrain and transmission, from the US, routing its parts shipments through National Transportation Idle-Free Corridors will help in lowering environmental impact.

Maximizing Rail Efficiency and Intermodal Operations

The third component of the SmartWay Transport Partnership is to encourage intermodal operations by highlighting practical opportunities for utilizing rail transport as a complement to truck shipment. Ton-mile for ton-mile, rail is a very efficient mode of transportation, and given India's extensive rail network (the highest track mileage in the world), VDS is well-positioned to benefit from the green efficiencies of intermodal transport through prudent transport planning.

Thus, the SmartWay Transport Partnership program provides an excellent framework for managing the environmental impact of parts transportation between supply chain nodes/tiers. Its attractiveness also stems from the practical metrics provided to program partners to use in measuring and calculating their environmental performance and accrued financial benefits (SmartWay Transport Partnership, 2007). It is estimated that adoption of all the fuel-saving strategies embodied in the SmartWay Transport Partnership can lead to a 100% increase in fuel efficiency by freight carriers.



Figure 9: Green transport solution for VDS supply chain

The above figure summarizes the green transportation solution for the VDS supply chain:

- (1) Overseas parts supplier uses trucking routed through one of the National Idle-free Corridors connected to a rail network node
- (2) Use of multi-modal transportation (i.e. truck to more energy-efficient rail transport) to minimize pollution where direct rail transport to sea port is not available
- (3) Use of direct rail transport to sea port whenever possible to avoid trucking
- (4) Consolidation of component supplies to minimize shipments and increase load efficiency
- (5) Selection of sea freight carriers using shortest possible route
- (6) Location of assembly/manufacturing plant at major port to minimize subsequent transloading and land transportation of supplies
- (7) Local suppliers use India's extensive rail network or multi-modal transport to avoid poor road infrastructure
- (8) Use of coastal shipping where possible to distribute new cars to dealers
- (9) Similarly, to reach dealers in inland cities, use rail or multi-modal land transportation where possible. Car tractor-transporters should incorporate green idle-reduction technologies recommended by SmartWay Transport Partnership.

5.4 Product Recovery

The Product Recovery function has long been a neglected part of automotive supply chains, where car manufacturers traditionally view Distribution and after-sales spares support as the end of their responsibility. The post-consumer phases of a car's life-cycle, namely Disposal and Recycling, have never been perceived as part of the manufacturers' supply chain until recently. Over the past decade, there has been increasing interest in Product Recovery within the automotive industry due partly to the economic benefits of engine remanufacturing (compared to production from scratch) and, especially, to the European Union's (EU) regulations on the treatment of automotive products after they have reached the end of their useful functioning periods – the so-called End-of-Life Vehicles (ELV), described below.

5.4.1 Description of Activities

An average passenger car consists of around 15,000 parts. Many of these, like the engine and transmission, have good commercial value as spares and are harvested by vehicle scrapyards before the rest of the vehicle's hulk is disposed by crushing in a compactor prior to sale as scrap metal to smelters or dumped at landfills. In Europe alone, approximately 12 million vehicles get discarded every year as they reach the end of their useful life. Fortunately, for decades, almost 75% of all discarded vehicles have been recycled. In fact no other consumer product has a recycling rate as high as the automobile. However, this is often done without any consideration of the liquids remaining in the vehicles' fuel tank, hydraulic system, radiator, axles etc. The numerous polymer-based parts are also left in place whereby they emit toxic fumes upon incineration at the smelting plant.

5.4.2 Sources of Pollution

Obviously, the ELV hulk itself is a source of pollution if it ends up rusting away in a landfill or casual junkyard. However, the contents of the ELV like the engine oil, radiator and air-conditioning coolant, hydraulic fluid, axle grease etc, and the non-biodegradable materials like silicon, plastic and paint are also pollutants and can result in harmful environmental effects if they leach into fresh water sources like rivers, lakes and underground water tables. The non-degradable solid materials like the car insulation and seat foam also consume precious landfill capacity.

5.4.3 Green Solution for ELVs

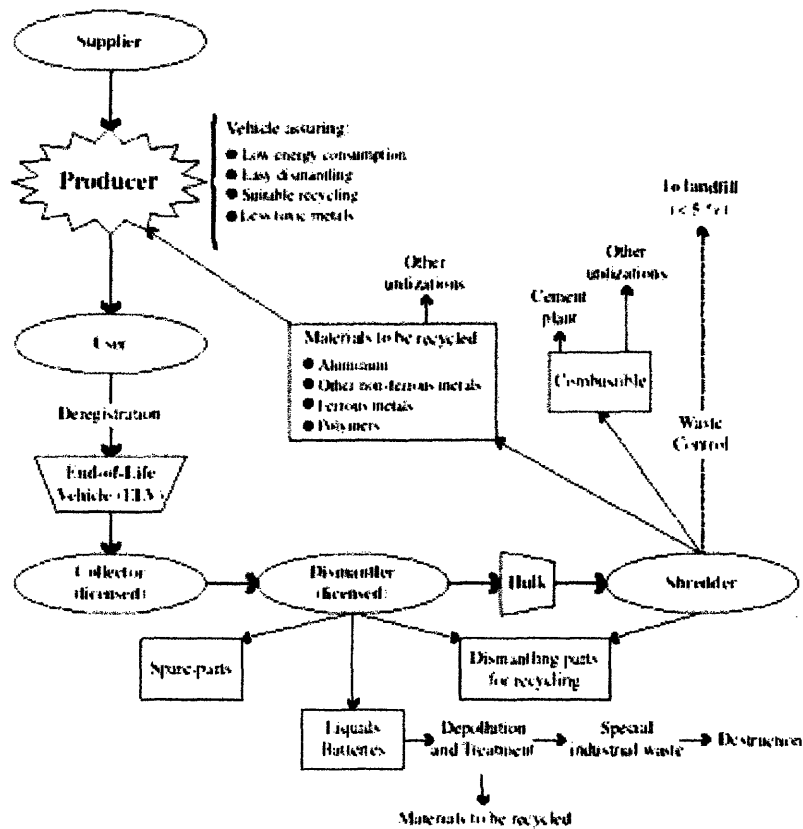
Recognizing the environmental threat stemming from improper disposal of ELVs, and to target the remaining 25% of unrecycled ELVs' impact on landfill capacity, the EU was the first to enact legislation governing the treatment of ELVs within Europe. The part of the EU's ELV directive (The European Commission, 2000) most essential to automotive manufacturers is contained in Article 7, which states that:

- 1. Member States shall take the necessary measures to encourage the reuse of components which are suitable for reuse, the recovery of components which cannot be reused and the giving of preference to recycling when environmentally viable, without prejudice to requirements regarding the safety of vehicles and environmental requirements such as air emissions and noise control.*
- 2. Member States shall take the necessary measures to ensure that the following targets are attained by economic operators:*

- a. *No later than 1 January 2006, for all end-of life vehicles, the reuse and recovery shall be increased to a minimum of 85% by an average weight per vehicle and year. Within the same time limit the reuse and recycling shall be increased to a minimum of 80% by an average weight per vehicle and year; for vehicles produced before 1 January 1980, Member States may lay down lower targets, but not lower than 75% for reuse and recovery and not lower than 70% for reuse and recycling. Member States making use of this subparagraph shall inform the Commission and the other Member States of the reasons therefore;*
- b. *No later than 1 January 2015, for all end-of life vehicles, the reuse and recovery shall be increased to a minimum of 95% by an average weight per vehicle and year. Within the same time limit, the re-use and recycling shall be increased to a minimum of 85% by an average weight per vehicle and year.*

The ultimate goal of the EU's ELV directive is to put only 5% of ELV residues, known as Automotive Shredder Residues (ASR) into landfills. Waste prevention, re-use, recycling, and recovery of the ELV constituents so as to reduce ASR waste disposal are the means prescribed in the EU ELV directive to achieve this goal. The ELV Directive does not set common EU-wide standards and systems for ELV collection and treatment, but leaves Member States to define how the prescriptions of the ELV Directive should be implemented in their territory. This has resulted in a plethora of regulatory options chosen by Member States to implement the ELV Directive. Some countries have taken a 'laid-back' approach while others chose to be proactive in terms of targets or deadlines (e.g., Germany, The Netherlands and Spain.)

A schematic representation of the participants in the ELV chain, based on the EU directive, is shown below. The main actor is the producer (either a vehicle manufacturer or professional importer of a vehicle into a member state of the European Union), who links the upstream (supplier) and downstream entities in the ELV chain (collector, dismantler, and shredder). As depicted in the figure, collaboration between producer, collector, dismantler, and shredder are necessary to successfully meet the directive's goals. The collaboration between these players represents the "close-loop" portion of the automobile supply chain.



Source: Journal of Minerals, Metals and Materials

Figure 10: ELV chain of activities

According to the EU ELV directive, the vehicle producer's responsibility is to ensure that the vehicle meets the following goals: has low energy consumption, designed for easy dismantling, has sufficient recyclable content, and contains no hazardous substances like lead, mercury,

cadmium and hexavalent chromium. To fulfill these goals, the producer has to have a good knowledge of the technical facilities, recyclability rate, and efficiencies of the downstream ELV chain. Also, the producer must provide the dismantling information for each new type of vehicle put on the market so as to facilitate material separation and sorting for proper treatment.

Following passage of this legislation on the treatment of ELVs by the EU, all of the major automotive manufacturers, EU and non-EU, formalized their products' recycling specifications to achieve compliance in the materials selection and product design dimensions. However, less substantial progress has been made with regards to the supply chain aspects of product recovery and reuse – i.e. to achieve what is called a “closed-loop” automotive supply chain. Automotive manufacturers favored the formation of alliances among themselves and, later, with local governments in a bid to spread out the costs involved in processing ELVs. Presently, the issue of the best approach to manage the Product Recovery function of the automotive supply chain in EU countries remains controversial, as economic and political interests guiding current vehicle production systems (e.g. governments' desire to protect their automotive industries) inhibit the development of closed-loop supply chain best practices for ELV management. However, three types of approaches have emerged:-

1. Fee-based. A non-profit organization collects a flat waste disposal fee from the first owner⁷. This fee subsidizes the cost of all activities associated with ELV processing.
2. Market-based. This entails relying on free-market mechanisms to achieve the ELV directive goals with minimal government intervention. Out-sourcing of ELV processing to certified third-party dismantling companies is popularly used by producers.

⁷ The EU ELV directive specifically prohibits passing on the cost of ELV treatment to the last owner of the vehicle.

3. Company-by-Company. Each producer is responsible for the management of ELVs under its own brand, and must provide evidence of compliance to monitoring agencies.

5.4.2 ELV Treatment in India and Implications for VDS

Despite the emphasis on ELV management in the EU and Japan⁸, there currently exists no equivalent legislation in India. This does not mean, however, that the situation will not change by the time VDS enters the Indian market. In fact, because Indian auto manufacturers and their multinational counterparts based in India have had to ensure compliance of their exports to ELV legislations enacted in the EU and Japan, the Indian automotive industry is, in fact, on track to becoming ELV-management capable at home within a few years. As ELV compliance knowledge and technology cascades from the Indian auto producers and multinational automotive component manufacturers to their Tier 1 and below suppliers, the industry will soon be ripe for the Indian government to enact similar ELV legislation to curb environmental damage from India's ballooning car population. Thus, from both a business and environmental responsibility standpoint, VDS must incorporate a Product Recovery function into its supply chain for ELV treatment of the Vision 200.

5.5 Summary of Green Solutions for VDS Supply Chain

The following diagram illustrates how the various green solutions identified in this chapter address the sources of pollution in each function of the VDS supply chain. The proposed framework for tying together the various green solutions into a manageable green supply chain for VDS will be covered in the next chapter.

⁸ Japan enacted its Automobile Recycling Law in January 2005, with many similar stipulations as the EU ELV directive.

ISO14001-compliant EMS adopted to provide an auditable framework for ensuring that the green solutions for each supply chain function are properly implemented and continuously improved upon.

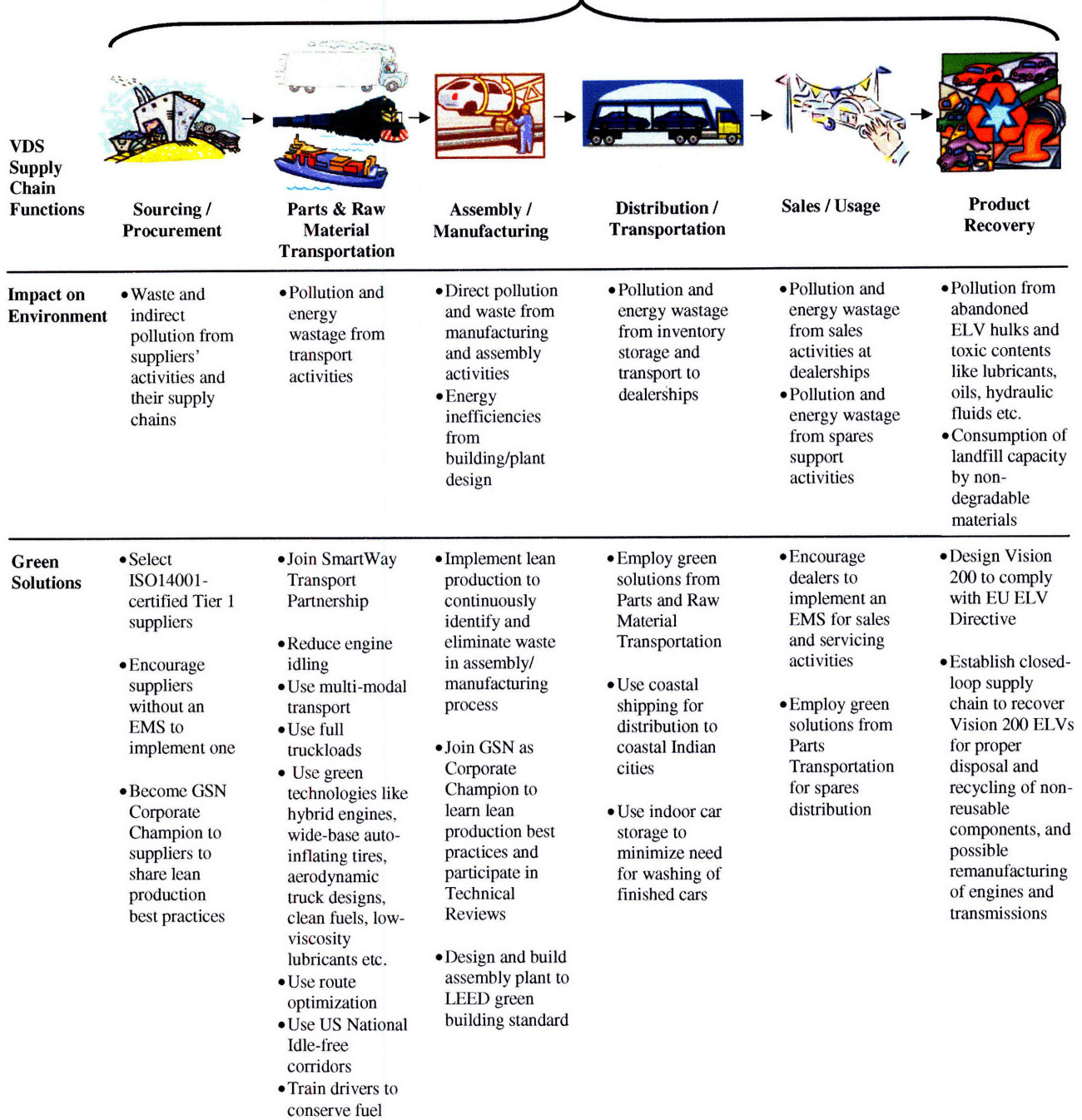


Figure 11: Summary of green solutions for VDS supply chain

Chapter 6 Environmental Management System (EMS) for the VDS Green Supply Chain

The preceding chapters have presented the hypothetical VDS supply chain, the potential sources of pollution within each of the four supply chain functions, and the proposed green solutions for each. This chapter presents the framework for tying all of the above together – a master plan for VDS to manage the green objectives of its supply chain.

6.1 Green Supply Chain Management using an EMS

Developing a green supply chain entails not only assembling the various environmental solutions, but also requires having a system to manage, monitor and improve upon what has been built. This is termed Green Supply Chain Management (GSCM) and we propose the use of a supply chain-wide EMS as the means for VDS to accomplish this.

6.1.1 Introduction to EMSs and their Benefits

An EMS is a strategic management framework that defines an organization's approach to addressing the impact of its operations on the environment. A good EMS should consist of the following key elements:

1. An environmental policy statement
2. A plan to uphold the stated policy, usually by internal assessments of the organization's environmental impacts (including quantification of those impacts and how they have changed over time)
3. Measures to ensure the plan is carried out, usually by creating quantifiable goals to reduce environmental impacts, providing resources, training workers and adopting environmental criteria to evaluate employee performance

4. Measures to continuously review the plan for effectiveness, usually by checking implementation progress through systematic auditing to ensure that goals are being reached; correcting deviations from goal attainment; and undergoing management review

The benefit of EMSs is that they help organizations embed environmental practices deep within their operational frameworks so that protecting the natural environment becomes an integral element of their overall business strategy (Shireman, 2003). For these reasons, EMSs have become recognized as systematic and comprehensive mechanisms for improving environmental and business performance. This is supported by research studies showing that organizations adopting EMSs are generally able to reap both environmental and economic gains, giving them considerable competitive advantage over companies without an EMS.

Traditionally, the scope of EMSs has been limited to the organizational boundaries of their adopters. With the emergence of new concepts like GSCM, requiring organizations to have greater influence over the activities of their supply chain partners, there is pressure to extend the EMS scope to the entire value chain, and not just within the organization itself. This is the key challenge in designing the EMS for VDS. Fortunately, there is evidence that the different elements of an EMS, mentioned above, are aligned with GSCM practices like assessing the environmental performance of suppliers, requiring suppliers to undertake measures that ensure environmental quality of their products, and evaluating the cost of waste in their operating systems (Darnall, Jolley, & Handfield, 2008).

6.2 EMS for VDS' Green Supply Chain

Whilst an EMS can take any format, and many different ones exist, the most widely-used is the format based on the ISO14001 standard, which follows Deming's "Plan-Do-Check-Act" (PDCA) framework to ensure that environmental issues are systematically addressed and continuously improved upon.

As described earlier in Chapter 2, the ISO14001 standard is not a performance standard and does not assess the effectiveness of the green solutions contained in the EMS. Instead, accrediting an EMS to the ISO14001 standard ensures that the organization "Says what it does, and does what it says" with respect to environmental protection in its operations. According to ISO, every ISO14001 requirement must be built into the EMS. However, the size and complexity of EMSs vary quite a bit, depending on the following factors:

1. The organization's size
2. Its location
3. The scope of its EMS
4. The content of its environmental policy
5. The nature of its activities, products, and services
6. The ecological impact of its environmental aspects⁹
7. The legal and other requirements that must be met

In the following sections, we will describe how the green solutions developed in chapter 5 can be incorporated into an EMS tailored for VDS' GSCM needs.

⁹ ISO defines an *environmental aspect* as a *feature or characteristic* of an activity, product, or service that affects or can affect the environment.

6.2.1 EMS Structure

There are four types of documents needed for an EMS:

1. EMS Manual – the main document
2. EMS Procedures – a set of documents describing the process and flow of activities, people involved, location and reason for the process
3. EMS Work Instructions – step-by-step instructions for performing a single activity, breaks a procedure into its individual parts
4. EMS Records – tracks the result of inspections, tests, or other actions; typically comprising forms used to record completion of required EMS activities

The EMS structure is illustrated in the document pyramid below.

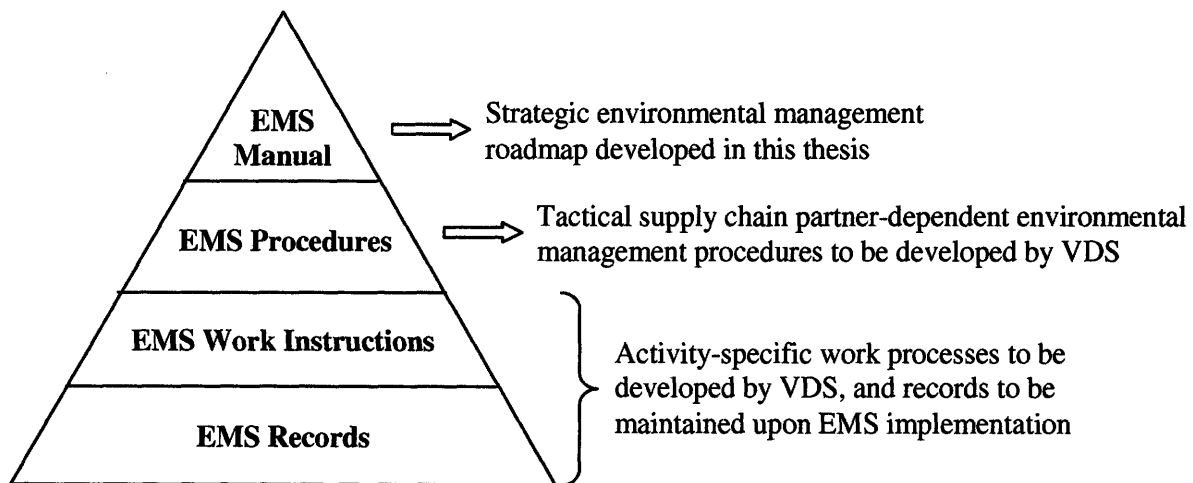


Figure 12: EMS document pyramid

As shown, the EMS Manual is the most critical as it serves as the master document for the rest by strategically laying out the roadmap to the organization's entire EMS. It is also the only part of the EMS that can be developed for VDS at this stage as the EMS Procedures and Work Instructions are tactical-level documents that require details of the specific work processes to be developed first. The list of EMS Procedures (EP-001 to EP-016) is proposed, but VDS will need

to develop each procedure based on the actual supply chain partners selected. Similarly, the list of appendices to the VDS EMS manual is proposed but cannot be developed at this point without the operational details of the VDS organizational structure and its interaction with its business environment being established first.

The role of the EMS Manual is to:

1. Outline the organization's environmental policies and objectives
2. Provide an overview of the EMS adopted to achieve those objectives
3. Address each of the 20 sub-clauses in ISO14001 Section 4
4. Reference the EMS Procedures (which, in turn, references the Work Instructions)
5. Explain the rationale for organization practices

Of the above, the most crucial is how the EMS Manual addresses the sub-clauses of Section 4 of the ISO14001 standard – also known as the EMS Requirements – in which the organization has to specify its PDCA framework for ensuring the environmental soundness of its operations.

Section 4 is thus the core of the ISO14001-based EMS to be tailored for VDS, and developing this using the green solutions for each of VDS' supply functions is the focus of this chapter.

6.2.2 ISO14001 Section 4 (EMS Requirements) for VDS EMS Manual

There are six sub-sections for the EMS Requirements which need to be customized for VDS' supply chain. These are presented below.

6.2.2.1 'EMS Requirements Section 4.1: General Requirements'

To manage its green supply chain, VDS will establish and maintain an EMS to the requirements described in ISO14001 standard. The proposed EMS Manual for VDS' green supply chain is given in Appendix B.

6.2.2.2 'EMS Requirements Section 4.2: Environmental Policy'

The environmental policy of VDS is:

1. To minimize the direct and indirect adverse environmental effects of all activities that are part of its value chain in the production of automobiles
2. To continuously improve on the processes adopted to minimize pollution
3. To comply with all environmental legislation and regulations in the countries spanned by its operations
4. To review the environmental objectives and targets for its supply chain to ensure continuous improvement
5. To document, implement, maintain and communicate to all employees and business partners its environmental management system

The VDS leadership must establish a Cross-Functional Team (CFT) comprising members from each of the supply chain functions of Sourcing/Procurement, Manufacturing, Distribution/Transport, Product Recovery, as well as Building Maintenance and Sales to steer the implementation and continued development of its environmental policy. The proposed structure of the CFT is shown below and also given in the EMS Manual for VDS.

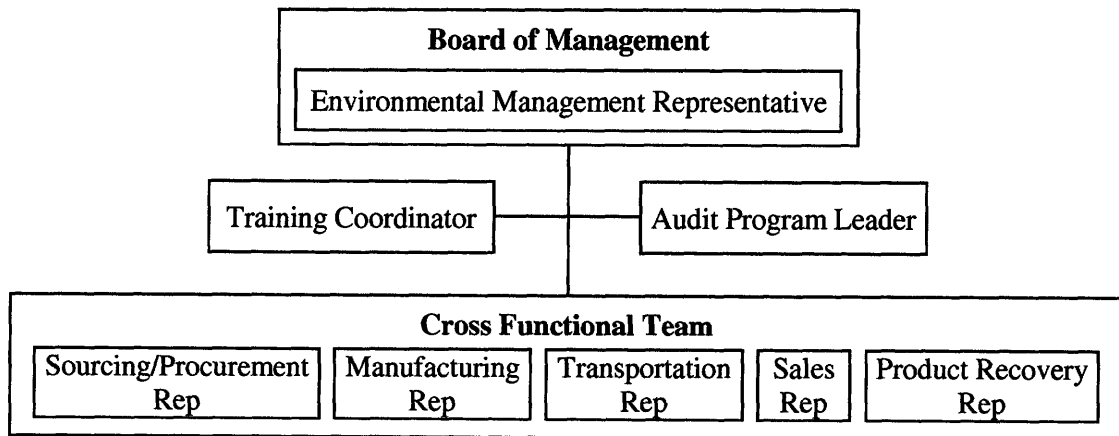


Figure 13: Proposed VDS EMS management structure

6.2.2.3 ‘EMS Requirements Section 4.3: Planning’

Section 4.3.1 Environmental Aspects

The environmental aspects of VDS’ supply chain (i.e. the potential sources of pollution from each function) have been identified in chapter 5. The VDS CFT must review these every six months at least, or whenever there is a new or changed activity in the supply chain. Records of the proceedings and decisions of each review must be maintained as part of the EMS documentation.

Section 4.3.2 Legal and Other Requirements

VDS must identify, access, communicate and review all industry codes of practice, legislation, agreements with public authorities and non-regulatory guidelines pertaining to environmental protection applicable to its supply chain functions. This must be done on an annual basis at least by the CFT.

Section 4.3.3 Environmental Objectives and Targets

The VDS CFT must develop objectives and targets to mitigate the effects of each environmental aspect identified in chapter 5. The objectives and targets define:

1. The performance objectives for each environmental aspect (i.e. Investigate/Study, Control/Maintain or Improve)
2. The specific, quantified target for each performance objective
3. The timeframe to achieve the set targets

The objectives and targets must be developed in consideration of not only the significance of the environmental aspects, but also the technological options and financial, operational and business plans, and the views of interested parties.

Section 4.3.4 Environmental Management Programs

Based on the green solutions proposed for each environmental aspect identified in chapter 5, the VDS CFT must establish environmental management programs (EMPs) to achieve the specified environmental objectives and targets. These EMPs define the principal actions to be taken, personnel responsible for undertaking those actions and the implementation timeframe.

6.2.2.3 'EMS Requirements Section 4.4: Implementation and Operation'

Section 4.4.1 Organizational Structure & Responsibility

The VDS leadership must appoint a member from its ranks as the Environmental Management Representative (EMR), to whom the CFT will report directly. The EMR is the top management member responsible for establishing, operating and maintaining the EMS. The EMR will lead the CFT in obtaining and providing resources essential to the implementation and control of the EMS, including: training, human resources, specialty services, financial resources, technical and informational services.

Section 4.4.2 Training, Awareness and Competence

VDS must establish and maintain procedures for identifying the environmental training needs of all personnel working in its organization – both employees and sub-contractors. It is the EMR's and CFT's responsibility to ensure the environmental competence of all personnel, especially those performing specialized environmental functions.

Section 4.4.3 Communication

VDS' effort and commitment to green its supply chain must be communicated to all internal and external stakeholders, as well as any interested parties. This requires a means to process requests for information and to disseminate it. A communications portfolio within the CFT is thus

required to produce electronic newsletter/bulletins on EMS updates and to handle information requests.

Section 4.4.4 EMS Documentation

All documents relevant to VDS' EMS, such as the EU ELV Directive and LEED Green Building Rating System etc., must be identified in the EMS Manual. The EMR, or designee from the CFT, must hold a complete copy of all EMS documentation.

Section 4.4.5 Document Control

To facilitate auditing and to ensure currency of information, EMS documentation must be properly tracked, reviewed and have any amendments controlled. This is also ultimately the responsibility of the EMR or designee in the CFT.

Section 4.4.6 Operational Control

The VDS CFT must establish operational controls for the activities associated with the supply chain's environmental aspects through the development of detailed EMS Procedures and EMS Work Practices. Briefly described in section 6.2.1, Procedures are supply chain-wide in their application and detail the processes that occur within VDS and between VDS and its partners, while Work Practices are step-by-step instructions for performing a specific activity within the VDS organization.

Section 4.4.7 Emergency Preparedness and Response

The VDS CFT must establish a procedure to identify and respond to potential accidents and emergencies that have negative environmental impact. These emergency procedures must be reviewed at least annually by the CFT, or after the occurrence of any accidents.

6.2.2.4 'EMS Requirements Section 4.5: Checking and Corrective Action'

Section 4.5.1 Monitoring and Measurement

VDS must establish a procedure to monitor and measure the effects of its supply chain activities on the environment. This requires calibration of appropriate measurement tools and maintenance of measurement records.

Section 4.5.2 Nonconformance and Corrective and Preventive Action

The VDS CFT must appoint an Audit Program Leader (APL) to handle and investigate nonconformance with the supply chain EMS. The APL will be also responsible for:

1. Coordinating action to mitigate the impact of nonconformance
2. Implement corrective action to prevent recurrence
3. Documenting and maintaining records of nonconformance and remedial actions

Section 4.5.3 Records

The VDS CFT must have a procedure for the management of EMS Records, including identification, maintenance and disposal of records pertaining to training, complaints, nonconformances, audits and corrective actions. These records must be readily retrievable and protected against damage, deterioration or loss. Each department within the VDS organization will be responsible for maintaining its own records and updating the CFT of any changes. The CFT will maintain a master EMS Records list and a copy of all records.

Section 4.5.4 EMS Audit

The VDS APL and EMR, together with the CFT, must establish an audit program with procedures covering the following:

1. Activities and areas of the supply chain (within the VDS organization) to be audited

2. Frequency of audits
3. Type of audit (i.e. internal or external 3rd-party audits) and methodology
4. Responsibilities and required competence for managing and conducting audits
5. Communication of audit results

6.2.2.5 'EMS Requirements Section 4.6: Management Review'

A cornerstone of the ISO14001 EMS standard is continuous improvement through regular review of the EMS by those responsible for designing and implementing it. Thus, the VDS leadership and the CFT must establish a review procedure meeting the following criteria:

1. Done at least annually
2. Covers audit results and follow-up activities
3. Assesses the continuing relevance of all EMS Requirements in relation to changes in the operating context of VDS' supply chain
4. Addresses the concerns of any stakeholder or interested party

6.3 Summary

The EMS requirements developed in this chapter for VDS' supply chain provide a robust framework for the VDS management to perform GSCM. While the proposed EMS Manual contains all the key elements necessary for VDS to measure its supply chain's environmental performance, it cannot replace the strong management commitment required of both VDS and its partners to ensure the supply chain remains green. Hence, the EMS Procedures and Work Processes, once developed, must be continually reviewed, improved and implemented if VDS' intent of having a green supply chain is to be kept alive.

Chapter 7 Results

The design of an automotive supply chain from scratch is by itself a daunting task. Including the requirement of environmental-friendliness complicates the endeavor considerably, and adding the constraints of an emerging market makes any attempt to create such an entity a near altruistic effort. Fortunately for VDS, being a potential start-up automotive company gives it a great advantage – the lack of any legacy systems to grapple with in planning its green supply chain. Because so much of a supply chain's costs and problems are determined during the planning phase, VDS has a golden opportunity to get things right from the beginning. A main complicating factor in this research is the fact that the Vision 200 is still undergoing development, and thus, no definitive product configuration details were available to use in planning. The same is true for the structure of the VDS commercial organization. The lack of product and organizational details notwithstanding, the research focused on the macro-level issues and identified the organizational, technical and management requirements for a green automotive supply chain in India.

This chapter presents first the research findings with regards to green automotive supply chains and their costs, value, implementation and upkeep. It concludes with specific recommendations for VDS to realize a green supply chain in India.

7.1 Research Findings

7.1.1 Value of Green Automotive Supply Chains

This thesis approached the research problem from both an environmental and a business value-creation perspective. It was recognized from the outset that a green supply chain had to first

fulfill its primary purpose of delivering financial value to VDS, or its stretch objectives of minimizing environmental impact would be meaningless (e.g. if VDS were to become bankrupt because of it). To constrain the problem further, a definition of a green supply chain and the challenges of an emerging market context were established.

Thus, we explored the management decision tools available to companies for environmentally-motivated investments. In particular, Environmental Cost Accounting is found to be an important tool for the VDS management to use in capital expenditure and production cost decisions. Using ECA, the financial value of green automotive supply chains is firmly established through the avoidance of future indirect internal costs, contingent costs and external costs.

Green automotive supply chains also bring value in the way their green solutions help to overcome the challenges of the Indian emerging market. For example, coastal shipping is not only environmentally-friendlier, it also provides one solution to the poor road infrastructure in India.

7.1.2 Cost of Green Automotive Supply Chains

From our study of the economics of GSCM and research into the costs involved in lean manufacturing and participation in programs like the SmartWay Transport Partnership, we find no evidence that the costs of operating a green supply chain is any higher than for a conventional supply chain. In fact, from ECA and TBL anecdotes, a green supply chain would cost less over the longer term to operate. This is not surprising considering that the bulk of a supply chain's cost is fixed at the design stage, as mentioned earlier. Thus, if prudent decisions are made at the beginning with regards to facility location, network design and capital investment, the set-up cost of a green supply chain would be comparable to a conventional one.

Another key factor accounting for the lower cost of a green automotive supply chain is the lean manufacturing effects. Since green supply chains are also lean supply chains, they tend to have lower costs due to the continuous identification and elimination of waste through *kaizen*.

7.1.3 Implementation of Green Solutions

The four main green solutions recommended in chapter 5 – greening Sourcing/Procurement and Manufacturing through the Green Suppliers Network, greening Transportation/Distribution through the SmartWay Transport Partnership, greening infrastructure through the LEED Green Building Program, and Product Recovery based on the EU ELV Directive – highlight a critical point: *that VDS does not need to ‘re-invent the wheel’ when attempting to green its supply chain.* Indeed, a key finding of this research is that many of the solutions for operating a green supply chain already exist, albeit in piecemeal form. Government agencies like the US EPA and EU have initiated high-quality programs like the GSN and SmartWay Transport Partnership which VDS can benefit through participation. Also, because the automotive industry is dominated by a handful of global suppliers for key components and materials like steel, rubber and vehicle power trains, VDS can reduce its supply chain’s environmental exposure significantly by partnering with these large suppliers to leverage their well-established environmental management programs.

Where possible, green solutions should be integrated with product development via concurrent engineering to achieve superior implementation. For example, supplier involvement in component design not only facilitates lean manufacturing and bid selection as discussed in Chapter 4, but also fosters ownership and commitment to execution.

7.1.4 Upkeep of Green Automotive Supply Chains

Setting up the green supply chain is only the beginning. The supply chain will only remain green if management commits the effort to maintain it that way. The ISO14001 EMS is a useful framework for managing green supply chains, but ultimately, even its continuous improvement tools will become useless if VDS' management do not continue to emphasize its importance to staff and supply chain partners.

7.2 Recommendations for VDS

Based on the findings above, the following are the key recommendations for VDS to realize a green supply chain in India:

1. Be clear on what green means and set objectives to meet the right requirements. For example, green is not the same as 'sustainable', which includes societal dimensions like workplace affirmative action etc. VDS should not be side-tracked by such issues.
2. During the initial critical supply chain design stage, the main focus is on facility location and network design. The bulk of the supply chain cost will be determined by the location of the manufacturing/assembly facility and the location of suppliers and dealerships. It is important to leverage tax and tariff breaks as much as possible.
3. VDS must also develop its supply chain requirements in parallel with the Vision 200 product design. Neither the supply chain network nor the product design should be finalized before the other. This concurrent engineering effort will allow for the key product-related environmental management issues to be identified early and their impact on the supply chain to be assessed and planned for.
4. During the operational stage, focus of VDS' green supply chain effort should be on Supplier Selection, Transportation and Product Recovery functions. Selecting and developing the right

Tier 1 supplier relationships is critical for successful lean production. Because of India's undeveloped land transportation infrastructure, more creative transport solutions will be required to overcome this problem and stay green. Product Recovery represents both a challenge and opportunity for VDS. There is currently no clear system for ELV disposal in India. VDS can pioneer this area as a profit channel as well as close the loop on its green supply chain.

5. It is important not to lose focus when planning green investments. VDS' management must instill the discipline of applying ECA for all green capital investments and product design decisions. Green investments should be pursued only if they make both environmental and financial sense.
6. It may be easier to establish a green supply chain than to run it. Management commitment is critical to maintain a true green supply chain as the continuous improvement requirement can cause organizational fatigue. The real challenge, then, is to keep up the stamina in implementing the EMS across the supply chain. The financial benefits are certain for VDS if it endures in managing its green supply chain well.

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Appendix A

Analysis of the Indian Automotive Industry

This appendix provides additional background information on the Indian automotive manufacturing landscape, including government industry development plans, industry performance and the key factors affecting its competitiveness vis-à-vis China, the world's largest emerging economy and, arguably, India's biggest competitor in the race to become a new major player in global automotive industry.

India's Automotive Mission Plan

The Indian government has launched an Automotive Mission Plan (AMP) to make the nation a world leader in the manufacture and design of automobiles and their components. India's automotive mission is articulated in the following statement:

“To emerge as the destination of choice in the world for design and manufacture of automobiles and auto components with output reaching a level of US\$145 billion accounting for more than 10% of the GDP and providing additional employment to 25 million people by 2016.” – Ministry of Heavy Industries & Public Enterprises, Government of India.

The government believes the next ten years will be an intense and critical time for India to establish itself in this industry (SIAM-ACMA, 2007). The automotive mission has 25 recommendations which are aimed at attracting investments of between \$35 and \$40 billion over ten years.

Growth of Indian Automotive Exports and Domestic Sales

A key element of the mission focuses on growing the country's automotive exports. Ravi Kant, Vice President of the Society of Indian Automobile Manufacturers (SIAM) believes that "The AMP provides a good framework for manufacturers to develop new products and meet the emergent needs of the mobility of people and transportation of goods, and at the same time become a global automotive hub. Use of Intelligent Transport Systems¹⁰ (ITS) in the national road network would also greatly improve the efficiency of the road network and transportation at the same time enabling improved safety. Implementation of AMP will increase manufacturing, create jobs, and in doing so, will catalyze not only the automotive industry but also India's growth." (SIAM-ACMA, 2007).

The consulting firm McKinsey & Co. and the Associated Chambers of Commerce and Industry of India have estimated that the global production of automobiles will reach \$1.9 trillion by 2015 – approximately \$700 billion of which will be produced in low-cost countries, including India. Similarly, exports from low-cost countries are expected to reach \$375 billion by 2015, which is more than five times the current level of about \$65 billion. India's share of this currently amounts to about \$9 billion, and could increase to approximately \$45 billion by 2015. This is evidenced by the fact that Suzuki and other OEMs have already looked to India for much of their procurement needs (Balakrishnan, Iyer, Seshadri, & Sheopuri, Indian Auto Industry at the Crossroads, 2006). Indian automotive exports have exhibited an average annual growth of 41.5% since 2001 with increases of 28% and 25% in 2005 and 2006 respectively. This is largely due to the government's AMP initiative mentioned earlier.

¹⁰ ITS is a new large-scale initiative being planned that utilizes various sensor technologies to achieve visibility and control over India's transport networks to enable people and goods to move more safely and efficiently through a state-of-the-art, intermodal transportation system.

Category	2001 - 02	2002 - 03	2003 - 04	2004 - 05	2005 - 06	2006 - 07
Passenger Cars	49,273	70,263	125,320	160,670	169,990	192,745
Utility Vehicles	3,077	1,177	3,049	4,505	4,489	4,403
MPVs	815	565	922	1,227	1,093	1,330
Total Passenger Vehicles	53,165	72,005	129,291	166,402	175,572	198,478
M&HCVs	4,824	5,638	8,188	13,474	14,078	18,838
LCVs	7,046	6,617	9,244	16,466	26,522	30,928
Total Commercial Vehicles	11,870	12,255	17,432	29,940	40,600	49,766
Three wheelers	15,462	43,366	68,144	66,795	76,881	143,896
Scooters	28,332	32,566	53,687	60,699	83,934	35,685
Motorcycles	56,880	123,725	187,287	277,123	386,054	545,887
Mopeds	18,971	23,391	24,078	28,585	43,181	37,566
Electric Two Wheelers	-	-	-	-	-	-
Total Two Wheelers	104,183	179,682	265,052	366,407	513,169	619,138
Total	184,680	307,308	479,919	629,544	806,222	1,011,278

Source: Society of Indian Automobile Manufacturers

Table A-1: India Automotive Exports from 2001 to 2006

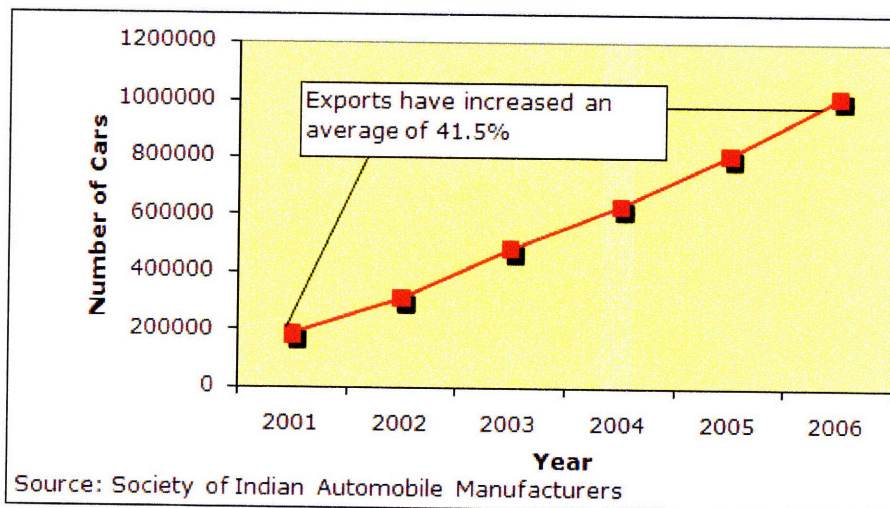


Figure A-1: India Automotive Exports from 2001 to 2006

The main challenge is perceived as sustaining the growth momentum for the medium and long terms into 2016. To this end, the automotive manufacturers must enhance their production accordingly (SIAM-ACMA, 2007). It is believed that success will bring substantial growth and benefits to India's economy (Goenka, 2007), possibly equal to that of Japan, South Korea or China. Growth of automotive exports from India has increased significantly over the past several years – statistics show that exports as a percentage of sales reached 13.1% in 2003-2004, a

significant increase from the 3.9% in 2003 (Balakrishnan, Iyer, Seshadri, & Sheopuri, Indian Auto Industry at the Crossroads, 2006).

Domestic sales within India have also fared quite well, trending upwards over the past seven years under the same catalysts as exports. Domestic sales have exhibited average annual growth of 14% since 2001, with increases of 12.8% and 13.5% in 2005 and 2006 respectively.

Category	2001 - 02	2002 - 03	2003 - 04	2004 - 05	2005 - 06	2006 - 07
Passenger Cars	509,088	541,491	696,153	820,179	882,208	1,076,408
Utility Vehicles	104,253	113,620	146,388	176,360	194,502	220,199
MPVs	61,775	52,087	59,555	65,033	66,366	83,091
Total Passenger Vehicles	675,116	707,198	902,096	1,061,572	1,143,076	1,379,698
M&HCVs	89,999	115,711	161,395	198,506	207,472	275,600
LCVs	56,672	74,971	98,719	119,924	143,569	192,282
Total Commercial Vehicles	146,671	190,682	260,114	318,430	351,041	467,882
Three Wheelers	200,276	231,529	284,078	307,862	359,920	403,909
Scooters	908,268	825,648	886,295	922,428	909,051	940,673
Motorcycles	2,887,194	3,647,493	4,170,445	4,964,753	5,810,599	6,553,664
Mopeds	408,263	338,985	307,509	322,584	332,741	355,870
Electric Two Wheelers	-	-	-	-	-	7,341
Total Two Wheelers	4,203,725	4,812,126	5,364,249	6,209,765	7,052,391	7,857,548
Total	5,225,788	5,941,535	6,810,537	7,897,629	8,906,428	10,109,037

Source: Society of Indian Automobile Manufacturers

Table A-2: India Automotive Domestic Sales from 2001 to 2006

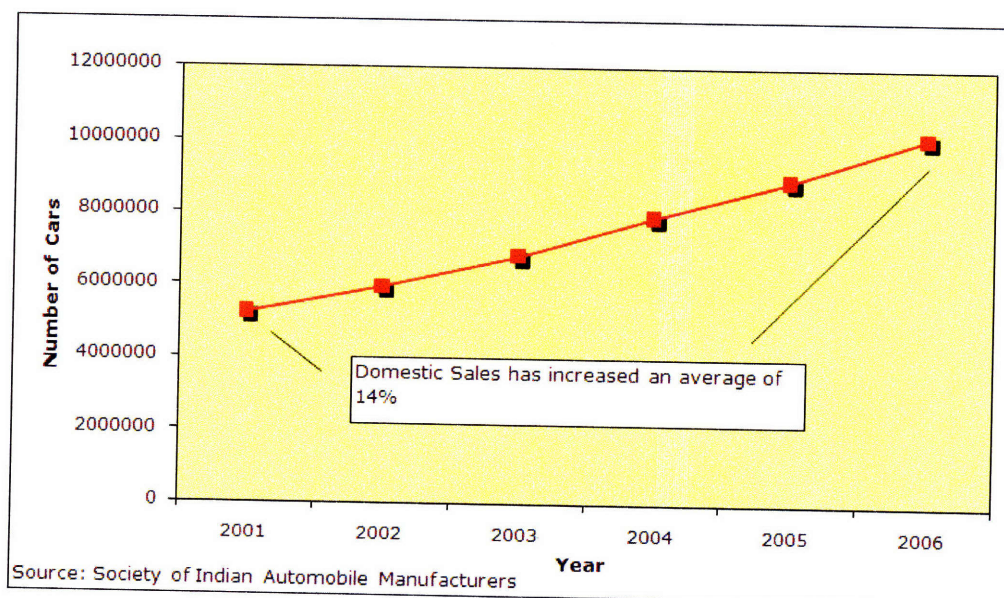


Figure A-2: India Automotive Domestic Sales from 2001 to 2006

Indian Automotive Component Industry

Since 2000, consolidation has significantly reduced the number of component producers in the marketplace. This industry rationalization has been driven by the displacement of Western assemblers by new, and considerably more efficient, Japanese and Korean firms. It is estimated that mergers, bankruptcies and firms exiting the industry have diminished the number of automotive component producers world-wide by approximately 80% over the past two decades (Noble, 2006). To leverage India's lower labor and production costs, many multinational automotive component manufacturers have shifted operations to India. The production of automotive components in India doubled between 2000 and 2006, when it grossed \$10 billion. The export of these components, including those incorporated in vehicles assembled for export, reached \$1.8 billion in 2006 (Noble, 2006).

The Indian automotive manufacturing industry's turnover was \$6.73 billion in 2003 versus a world-wide industry turnover of \$737 billion. At a 5-year Cumulative Annual Growth Rate (CAGR) of 20-25%, the growth in automotive component exports surpassed that of total domestic sales in India during this period, which was 10-14%. Despite higher raw material and energy costs compared to China, there has been a surge of multinational OEMs entering India to produce cars using competitively-priced locally-made parts (Balakrishnan, Iyer, Seshadri, & Sheopuri, Indian Auto Industry at the Crossroads, 2006).

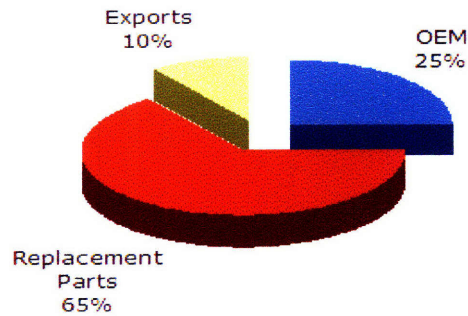


Figure A-3: Sources of Demand for Automotive Components Produced in India in 2004

The breakdown of demand for automotive components produced in India is shown in the above pie-chart. Original Equipment Manufacturers (OEMs) account for approximately 25% of the total demand within this market, while approximately 65% of the demand is from the replacement parts market, followed by the export market with approximately 10% of demand. These exports are primarily to Tier 1 suppliers.

The automotive components industry can be divided into six segments: Engine parts, Electrical parts, Drive Transmission & Steering parts, Suspension & Braking parts, Equipment and Miscellaneous or other components. The following table exhibits the cumulative annual growth rate (CAGR) of sales profits and exports of each segment between 1998 and 2003 (Balakrishnan, Iyer, Seshadri, & Sheopuri, Indian Auto Industry at the Crossroads, 2006).

<i>Segment</i>	<i>Sales</i>	<i>Profits</i>	<i>Exports</i>
<i>Braking parts</i>	9.59%	15.56%	17.03%
<i>Electrical parts</i>	2.77%	16.30%	9.35%
<i>Engine parts</i>	7.71%	16.80%	10.72%
<i>Equipment</i>	14.13%	16.83%	14.73%
<i>Other</i>	14.45%	25.93%	3.06%
<i>Steering</i>	10.43%	66%	1.88%

Source: CMIE Prowess

Table A-3: CAGR of Indian Automotive Component Industry Segments from 1998 to 2003

The main players within the Indian automotive component industry are primarily family businesses such as the Anand group, Rane group and TVS group. Each of these segments share similar basic cost structures such as material costs, employee costs and other manufacturing

costs, which collectively account for 70.4% of the industry's total operating income. Component complexity is an important determinant of cost – for example, engine manufacturing and assembly carries high employee costs due to the labor intensity of the process (Balakrishnan, Iyer, Seshadri, & Sheopuri, Indian Auto Industry at the Crossroads, 2006).

	Equipment Parts	Braking Parts	Steering Parts	Electrical Parts	Engine Parts
Raw Material Cost	62%	72%	70%	66%	47%
Power and Fuel cost	3%	3%	5%	2%	4%
Employee Cost	17%	8%	11%	12%	23%
Consumable Stores	1%	4%	4%	1%	7%
Selling Cost	6%	4%	3%	1%	5%
Other	11%	9%	7%	18%	14%

Source: Morgan Stanley

Table A-4: Cost Structure within the Indian Automotive Component Sector in 2004

As shown in the table below, Material and Employee costs constitute the bulk of the Indian automotive component industry's costs as a percentage of operating income. This is similar to those of the US market.

Material Cost	51.30%
Power and Fuel Cost	3.80%
Employee Cost	12.50%
Other expenses	17.10%
Selling expenses	3.30%
Interes & Finance Cost	3.60%
Depreciation	6.40%
Tax	2.00%

Source: Balakrishnan, Iyer, Seshadri, Sheopuri

Table A-5: Cost Breakdown within the Indian Automotive Component Industry as Percentages of Operating Income

Key Economic Drivers in the Indian Automotive Industry

Balakrishnan, Iyer, Seshadri & Sheopuri (2006) identified the following four factors as the key issues confronting the competitiveness of the Indian automotive industry.

Power and Infrastructure

China's cost of power is 30% to 40% lower than that of India (Balakrishnan, Iyer, Seshadri, & Sheopuri, Indian Auto Industry at the Crossroads, 2006). This is an important consideration since automotive production is a highly-automated and power-intensive process. In terms of infrastructure, data exhibited in a report issued by the ICRA (formerly the Investment Information and Credit Rating Agency of India Ltd) in 2004 indicate that the time required to transport products to the US from factories in India is 4 to 9 weeks longer than from China. This may be attributed to the less developed highway and port infrastructure in India, and would remain a problem for some time since infrastructural improvements require both strong budgetary commitments and political resolve to realize (Balakrishnan, Iyer, Seshadri, & Sheopuri, Indian Auto Industry at the Crossroads, 2006).

Tariffs

The ICRA report of 2004 also estimates that tariffs account for 10.8% of the cost of a car made in India versus one produced in China. An interview with the supply chain director of a major multinational automotive OEM indicated that cars imported *into* India for sale in the domestic market are subject to a tariff equal to 100% of the retail value of the vehicle. These tariffs are levied to protect the Indian domestic automotive market from foreign players only and do not apply to cars made for export. For example, the tariff on materials brought into India for automotive production is 7.6% but this is waived if the end product is exported. In this case, India would benefit from the employment generated by automotive manufacturing activities brought in by the multinational automotive manufacturers without subjecting its own automotive companies to increased domestic competition (Balakrishnan, Iyer, Seshadri, & Sheopuri, Indian Auto Industry at the Crossroads, 2006).

Cost of capital

Between 1997 and 2000, China's interest rates on five-year bond notes decreased from 7.8% to 4.9% while India's increased from 6.4% to 7.8%. Since 2000 however, decreases in India's administered interest rates have resulted in lending rates lower than those in China. Analysts have estimated that a 10% fall in interest rates translates to a 30% increase, on average, in profits before taxes for larger Indian corporations (Balakrishnan, Iyer, Seshadri, & Sheopuri, Indian Auto Industry at the Crossroads, 2006).

Government Policy

To encourage foreign direct investment (FDI) in the automotive industry, India adopted a policy of no minimum investment amount in 2002. This contrasts with China's policy, adopted in 2004, requiring 100% of investments in the automobile and component sectors to be from FDI to qualify for automatic approval (i.e. without obtaining prior approval from the government or central bank) (Balakrishnan, Iyer, Seshadri, & Sheopuri, Indian Auto Industry at the Crossroads, 2006).

To facilitate consolidation in the highly fragmented Chinese automotive market, China has imposed restrictions on the import of foreign cars through controlling the number of ports that may be used to bring in foreign-made vehicles, as well as by controlling the distribution channels for both local and imported cars. In India, both the automotive component manufacturers and the OEMs face similar 'protectionist barriers' – for example, under a government mandate, any foreign automotive component manufacturer entering the Indian market must achieve 50% local content within three years and 70% within 5 years (Balakrishnan, Iyer, Seshadri, & Sheopuri, Indian Auto Industry at the Crossroads, 2006).

Summary

India's competitiveness in the automotive industry vis-à-vis China stems primarily from lower engineering costs at the firm-level. Labor and logistics costs (due to less developed infrastructure) are higher in India compared to China, but the situation is improving. Also, India's tariffs and taxes are also currently higher compared to China's – though this may be negated with greater sourcing of local content by Indian-based OEMs.

Appendix B

4.0 EMS REQUIREMENTS

OF

EMS MANUAL FOR VDS GREEN SUPPLY CHAIN

(BASED ON ISO14001 STANDARD)

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List of EMS Procedures

EP-001 Formatting Environmental Procedures, Work Practices and Forms
EP-002 Environmental Aspects, Objectives and Targets, and Management Programs
EP-003 Environmental Management System and Regulatory Compliance Audits
EP-004 Non-Conformance and Corrective and Preventive Action
EP-005 Environmental Management System Management Review
EP-006 Emergency Preparedness and Response
EP-007 Environmental Regulations and Other Requirements
EP-008 Environmental Review of Projects
EP-009 Environmental Management Structure and Responsibility
EP-010 Environmental Communication
EP-011 Employee Environmental Competence
EP-012 Environmental Document Control
EP-013 Environmental Records
EP-014 Environmental Training and Awareness
EP-015 Monitoring and Measurement
EP-016 Environmental Document Control

List of EMS Manual Appendices

Appendix A Policy
Appendix B Aspects, Objectives & Targets
Appendix C Legal and Other Requirements
Appendix D Management Programs
Appendix E EMS Management Terms of Reference
Appendix F Training Matrix
Appendix G Master Document List
Appendix H Master Records List
Appendix I Procedures
Appendix J Work Practices

1.0 Purpose

This manual defines the scope of VDS' Environmental Management System (EMS) and provides a linkage of system documents to the various elements of the ISO14001 standard.

The principal elements of the system described in this manual are:

- Environmental Policy
- Environmental Aspects
- Legal and Other Requirements
- Environmental Objectives and Targets
- Environmental Management Programs
- Organizational Structure and Responsibility
- Training, Awareness and Competence
- Communication
- Document Control
- Operational Control
- Emergency Preparedness and Response
- Monitoring and Measurement
- Nonconformance and Corrective and Preventive Action
- Records
- Environmental Management System Audit
- Management Review

2.0 Scope

The VDS EMS provides a mechanism for environmental management throughout its entire supply chain. The EMS is designed to cover environmental aspects which VDS can control and directly manage, and those it does not control or directly manage but would have an influence over.

3.0 Issue and Update

The control of this Manual is in accordance with the VDS EMS environmental procedure EP-016 Environmental Document Control. All copies of this Manual not marked "CONTROLLED DOCUMENT" are uncontrolled and should be used for reference purposes only.

Amendments to this manual will be issued by the Environmental Management Representative (EMR) or designee following approval by the VDS Board of Management.

4.0 Environmental Policy

The environmental policy of VDS is endorsed by the Board of Management. It is as follows:

1. To minimize the direct and indirect adverse environmental effects of all activities that are part of its value chain in the production of automobiles
2. To continuously improve on the processes adopted to minimize pollution
3. To comply with all environmental legislation and regulations in the countries spanned by its supply chain
4. To review the environmental objectives and targets for its supply chain to ensure continuous improvement
5. To document, implement, maintain and communicate to all employees and business partners its environmental management system

Reference Material

ISO14001 Standard (4.2)

Applicable Procedures

EP-010 Environmental Communication

5.0 Environmental Aspects

The environmental aspects of VDS' supply chain are identified by the VDS Cross-Functional Team (CFT). It is reviewed every six months or whenever there is a new or changed activity in the supply chain. Discussions regarding significance are recorded in CFT meeting minutes, which are approved and maintained by the Environmental Management Representative (EMR), or designee, as part of the EMS Records.

A list of all aspects by supply chain function is included in Appendix B - Aspects, Objectives & Targets.

Reference Material

ISO14001 Standard (4.3.1)

Applicable Procedures

EP-002 Environmental Aspects, Objectives and Targets, and Management Programs

EP-008 Environmental Review of Projects

6.0 Legal and Other Requirements

VDS has established a procedure to identify, access, communicate and review all industry codes of practice, legislation, agreements with public authorities and non-regulatory guidelines pertaining to environmental protection applicable to its supply chain functions. The review is performed annually by the Environmental Coordinator of the CFT to ensure currency with national, regional, provincial, state and local legal and other requirements. A list of Legal and Other Requirements is given in Appendix C.

Reference Materials

Legal and Other Requirements

ISO14001 Standard (4.3.2)

Applicable Procedures

EP-007 Environmental Regulations and Other Requirements

7.0 Environmental Objectives and Targets

The VDS CFT has developed objectives and targets to mitigate the effects of each environmental aspect identified in EP-002. The objectives and targets define:

1. The performance objectives for each environmental aspect (i.e. Investigate/Study, Control/Maintain or Improve)
2. The specific, quantified target for each performance objective
3. The timeframe to achieve the set targets

The objectives and targets are developed in consideration of not only the significance of the environmental aspects, but also the technological options and financial, operational and business plans, and the views of interested parties. Appendix B - Aspects, Objectives & Targets identifies the VDS' supply chain's objectives and targets.

Reference Material

ISO14001 Standard (4.3.3)

Applicable Procedures

EP-002 Environmental Aspects, Objectives and Targets, and Management Programs

EP-008 Environmental Review of Projects

8.0 Environmental Management Programs

VDS' CFT has established environmental management programs (EMPs) to achieve the specified environmental objectives and targets. These EMPs define the principal actions to be taken, personnel responsible for undertaking those actions and the implementation timeframe.

The EMPs are developed by the CFT and approved by the EMR and VDS Board of Management (refer to Section 5.0 Environmental Aspects). The EMPs are given in Appendix D - Management Programs.

Reference Material

ISO14001 Standard (4.3.4)

US EPA Lean and Green Supply Chain Report

Green Suppliers Network Guide to Value Stream Mapping

SmartWay Transport FLEET Model for Shippers and Carriers

LEED Green Building Rating For Commercial Interiors

EU Directive 2000/53/EC on ELVs

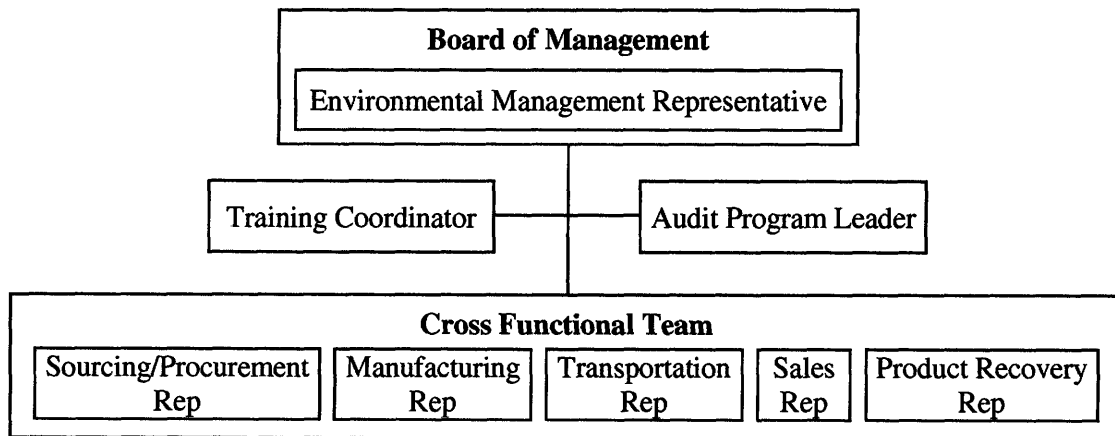
Applicable Procedures

EP-002 Environmental Aspects, Objectives and Targets, and Management Programs

EP-008 Environmental Review of Projects

9.0 Organizational Structure & Responsibility

Environmental management system roles, responsibilities and authorities are defined at relevant functions and levels within VDS. The EMR will lead the CFT in obtaining and providing resources essential to the implementation and control of the EMS, including: training, human resources, specialty services, financial resources, technical and informational services. The CFT provides routine EMS support and reports directly to the EMR. Documentation, which describes the various positions, is included in EP-009 Environmental Management Structure & Responsibilities. The VDS EMS organization chart is shown below:



Reference Material

ISO14001 Standard (4.4.1)

Applicable Procedures

EP-009 Environmental Management Structure & Responsibilities

10.0 Training, Awareness and Competence

VDS identifies, plans, monitors and records the environmental training needs of all personnel working in its organization – both employees and sub-contractors. It is the EMR's and CFT's responsibility to ensure the environmental competence of all personnel, especially those performing specialized environmental functions, so they are aware of the environmental policy, significant environmental aspects, their roles and responsibilities in achieving conformance with the policy and procedures, and with the requirements of the environmental management system. The Training Coordinator is responsible for maintaining employee training records. Appropriate records are monitored and reviewed on a scheduled basis. Competency is determined by the

employee's supervisor as specified in EP-011. An environmental training plan is in Appendix F - Training Matrix.

Reference Material

ISO14001 Standard (4.4.2)

11.0 Communication

VDS' effort and commitment to green its supply chain is communicated to all internal and external stakeholders, as well as any interested parties, by a procedure for internal and external communications regarding environmental aspects and the EMS. A communications portfolio within the CFT is also established to produce electronic newsletter/bulletins on EMS updates and to handle information requests.

Reference Material

ISO14001 Standard (4.4.3)

Applicable Procedures

EP-010 Environmental Communication

12.0 EMS Documentation

This Manual identifies all documents relevant to the EMS. A copy of the EMS documents can be obtained from the EMR or designee. System procedures and forms are provided in Appendix I (EMS Procedures) and Appendix J (EMS Work Practices).

Reference Material

ISO14001 Standard (4.4.4)

13.0 Document Control

VDS has established an environmental procedure for controlling all documents related to the environmental system. This procedure describes where documents can be located and how and when they are reviewed. The procedure ensures that current versions are available and that obsolete documents are promptly removed from use or are suitably identified. Controlled documents are obtainable from the EMR or designee. A list of controlled documents is provided in Appendix G - Master Document List.

Reference Material

ISO14001 Standard (4.4.5)

Applicable Procedures

EP-001 Formatting Environmental Procedures, Work Practices & Forms
EP-012 Environmental Document Control

14.0 Operational Control

VDS has established operational controls for the activities associated with the supply chain's environmental aspects through the development of detailed EMS Procedures and EMS Work Practices.

These documents define the mechanisms for the establishment, implementation and maintenance of the EMS and ensure that the system is maintained in accordance with the environmental policy and objectives and targets and is communicated to suppliers and contractors.

EMS Procedures (See Appendix I): Cover the management and control of both the EMS and the principal environmental aspects, which the system manages. These procedures are supply chain-wide in their application.

Work Practices (See Appendix J): Cover the environmental control of specific operational activities and are usually activity-specific in their application.

Reference Material
ISO14001 Standard (4.4.6)

15.0 Emergency Preparedness and Response

VDS has established a procedure to identify and respond to potential accidents and emergencies that have negative environmental impact. These emergency procedures are reviewed at least annually by the CFT, or after the occurrence of any accidents.

Reference Material
ISO14001 Standard (4.4.7)

Applicable Procedures
EP-006 Emergency Preparedness and Response

16.0 Monitoring and Measurement

VDS has established a procedure to monitor and measure the effects of its supply chain activities on the environment. This includes calibration of appropriate measurement tools and maintenance of measurement records, as well as an Environmental Regulatory Compliance Program.

Procedure EP-003 outlines the requirements of the program which covers periodic review of regulatory compliance and reporting of results to management annually.

Reference Material
ISO14001 Standard (4.5.1)

Applicable Procedures

EP-003 Environmental Management System and Regulatory Compliance Audits

EP-015 Monitoring and Measurement

17.0 Nonconformance and Corrective and Preventive Action

VDS has an environmental procedure for defining responsibility and authority for handling and investigating nonconformance, for taking action to mitigate impacts, and for initiating and completing corrective and preventive action. Any changes in procedures resulting from corrective and preventive actions are implemented and recorded. The Audit Program Leader maintains these records.

Reference Material

ISO14001 Standard (4.5.2)

Applicable Procedures

EP-004 Non-Conformance and Corrective and Preventive Action

18.0 Records

VDS has a procedure for the management of EMS Records, including identification, maintenance and disposal of records pertaining to training, complaints, nonconformance, audits and corrective actions. These records are readily retrievable and protected against damage, deterioration or loss. Each department within the VDS organization is responsible for maintaining its own records and updating the CFT of any changes. The CFT maintains a Master EMS Records List (see Appendix H) and a copy of all records.

Reference Material

ISO14001 Standard (4.5.3)

Applicable Procedures

EP-013 Environmental Records

19.0 EMS Audit

Periodic audits are conducted to ensure that the EMS has been properly implemented and maintained. The results of these audits are provided to management. Audits are performed according to the environmental importance of an activity, the results of previous audits and the audit schedule. All auditors are trained and audit records are kept with the Audit Program Leader.

Reference Material

ISO14001 Standard (4.5.4)

Applicable Procedures

EP-003 Environmental Management System and Regulatory Compliance Audits

20.0 Management Review

The VDS Board of Management reviews all elements of the EMS annually to ensure its continuing suitability, adequacy and effectiveness. Minutes of these reviews are recorded and kept by the EMR or designee.

Reference Material

ISO14001 Standard (4.6)

Applicable Procedures

EP-005 Environmental Management System Management Review

21.0 Record of Revisions

Revision Date	Description	Sections Affected