UNIVERSITY OF GOTHENBURG
SCHOOL OF BUSINESS, ECONOMICS AND LAW

Integrating Environmental Cost Information in Logistics Network Management

-A Case study for Volvo Logistics

Erick Flores and Tristan Jenkin

Graduate School

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Supervisor: Leif Enarsson

"Do not go where the path may lead, go instead where there is no path and leave a trail."

– Ralph Waldo Emerson

Abstract

This thesis was conducted in cooperation with the Core Values department at Volvo Logistics and Handelshögskolan, Gothenburg University in Gothenburg, Sweden. The objective of this study is two fold:

(i) To develop a system capable of providing environmental cost information to decision makers at Volvo Logistics in a timely and effective manner in order to incorporate emission levels as a key performance indicator in logistics network management and;

(ii) To conduct scientific research which meets the requirements of the academic community and produces new academic knowledge regarding the integration of environmental cost information in logistics network management.

In order to fulfill both of these objectives, the authors conducted three months of qualitative case study research at Volvo Logistics, involving an interdisciplinary focus on environmental sciences, logistics management, and the development of lean information systems. This research was conducted to explore, describe, and analyze the challenges and concepts behind the problem at Volvo Logistics and to develop a practical solution.

Acknowledgments

We would like to thank our family and friends for the support and encouragement they have provided us throughout this thesis. Even though they may be far away, they are always there in spirit. Special thanks to Emily and Nina for their support, dedication, and understanding without which we would be lost.

Also, we would like to thank all the people at Volvo Logistics for their help and collaboration during this endeavour, particularly to our supervisor Agneta Carlsson for believing in us from the start and giving us this opportunity.

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Table of Abbreviations

GHG	Greenhouse Gas
VLC	Volvo Logistics Corporation
IS/IT	Information System / Information Technology
GBO	Global Business Operation
KPI	Key Performance Indicator
EIA	Environmental Impact Assessment
CO_2	Carbon Dioxide
NO_x	Nitrogen Oxides
SO_x	Sulphur Oxides
PM	Particulate Matter
ILD	Inbound Logistics Development
CPR	Collaborative Practice Research
EMS	Environmental Management System
EMAS	EU Eco-Management and Audit Scheme
ISO	International Organization for Standardization
NTM	Network for Transport and the Environment
IVL	Swedish Environmental Research Institute
ELU	Environmental Load Unit
IMPACT	Internalization Measures and Policies for All External Costs of Transport
EDI	Electronic Data Interchange
3PL	3rd Party Logistics
TIR	Transport Information Rutiner
FADS	Forwarding Information System
CIC	Cost Invoice Control
THU	Terminal Handling Unit
ATLAS	Advanced Total Logistics for Automotive Supply
FTL	Full Truck Load
LTL	Less than Truck Load

Thesis Disposition

Chapter 1 ***Chapter 2***	***Part 1 – Introduction and Research Methodology*** *Part 1 introduces the thesis objective and research questions. A detailed description of the research methodology along with the scope and limitations of the study will also be presented. Part 1 is intended to lay the groundwork for this thesis so the reader will understand the purpose of the study and how it will be conducted.*
Chapter 3 ***Chapter 4*** ***Chapter 5*** ***Chapter 6***	***Part 2 – Research and Analysis*** *Part 2 consists of four chapters pertaining to the research and analysis conducted in this thesis. Chapter 3: Conceptual Framework, introduces the lean systems concept applied to people, processes, and technology at Volvo Logistics. Chapter 4: Contextual Framework, presents the research conducted on current trends and challenges in the field of logistics management, information technology, and environmental science, which are relevant to the research problem. Chapter 5: Empirical Framework, presents the empirical data collected throughout the case study at Volvo Logistics. Chapter 6: Empirical Analysis, analyzes this data in relation to people, processes, and technology in order to uncover the root causes of the problem and formulate a solution.*
Chapter 7 ***Chapter 8*** ***Chapter 9***	***Part 3 – Solution Proposal and Conclusion*** *Part 3 is comprised of the solution proposal for Volvo Logistics and the thesis conclusion. The proposed solution is based on the concept of lean systems development applied to people, processes, and technology. The people and processes components of the solution are presented together in Chapter 7 while technology is presented in Chapter 8. Chapter 9 presents the thesis conclusion, including a discussion on the application of the lean systems concept at Volvo Logistics and recommendations for future research and development in the field of logistics management.*

Part 1

Introduction
&
Research Methodology

Part 1 introduces the thesis objective and research questions. A detailed description of the research methodology along with the scope and limitations of the study will also be presented. Part 1 is intended to lay the groundwork for this thesis so the reader will understand the purpose of the study and how it will be conducted.

"If we knew what it was we were doing, it would not be called research, would it?"

— Albert Einstein

Chapter 1:

Introduction

This introductory chapter presents the background and focus of this thesis. The thesis objective is presented in relation to an environmental initiative underway at Volvo Logistics. This is followed by a number of academic research questions to be answered in the study and a problem discussion. The chapter concludes with a discussion on scope and delimitations of the study.

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1.1 Background

The fate of our planet rests in the choices we make today. Temperatures are rising at an alarming rate, ice caps are melting, erratic weather patterns are emerging, and water resources are depleting. Unless we reduce greenhouse gas (GHG) emissions by 80% by 2050, experts say global climate change will have a devastating impact on the face of the planet and the future of our children. But with this challenge comes incredible opportunity – to create jobs, renew communities, and reduce the harmful emissions that affect our health and the health of our environment (Clinton Climate Initiative 2009).

The most recent Assessment Report by the Intergovernmental Panel on Climate Change (IPCC) has determined it is very likely that GHG caused by human activity have already impacted the global climate (IPCC 2007). Two-thirds of these anthropogenic GHG emissions arise from the combustion of fossil fuels in sectors such as energy, construction, manufacturing, and transportation. In Sweden the logistics and transport sector is responsible for approximately 30% of GHG emissions (EPA, Naturvårdsverket 2008). Furthermore, emission levels from the transport sector have increased by 8% in the past fifteen years. This is the only economic sector in which GHG emissions have increased over this period (European Commission 2009).

The Stern Review (2006) states that climate change presents very serious global risks and it demands an urgent global response from both the private and public sectors. The logistics and transport sector is therefore faced with a bold challenge; logistics service providers are under pressure to not only reduce costs, but to also reverse the trend of increasing emissions and monitor progress towards corporate and legislated emission reduction targets. To do so they must first have a reliable and practical way to measure and account for their environmental impact.

In light of this situation,

"Volvo Logistics currently lacks the capability to perform adequate environmental impact assessments to measure and account for its emissions from inbound logistics operations."

– Per Palm, VLC Inbound Logistics Development

1.2 Thesis Objective

This thesis addresses the above-mentioned challenge confronting Volvo Logistics (VLC). In doing so, the authors present an information system/information technology (IS/IT) solution to facilitate VLC in performing environmental impact assessments.

The research objective of this thesis is to develop a system capable of reporting emission levels to decision makers in a timely and effective manner, in order to incorporate environmental impacts as a key performance indicator in logistics network management.

1.3 The Volvo Group and Volvo Logistics

1.3.1 The Volvo Group

The Volvo Group, otherwise referred to as AB Volvo, is a Swedish supplier of commercial vehicles, drive systems, aerospace components and financial services (AB Volvo 2009). The company was founded on 14 April 1927 in Gothenburg, Sweden, as a spin-off from the roller ball bearing maker SKF. Today the Volvo Group is a publicly traded company on the Stockholm Stock Exchange with a market capitalization of 100 billion Swedish Kronor (Financial Times 2009). Headquartered in Gothenburg, Sweden, the Volvo Group has over 90 000 employees in fifty-eight countries. As shown in Figure 1-1, the Group is comprised of the nine business areas supported by five business units (AB Volvo 2009).

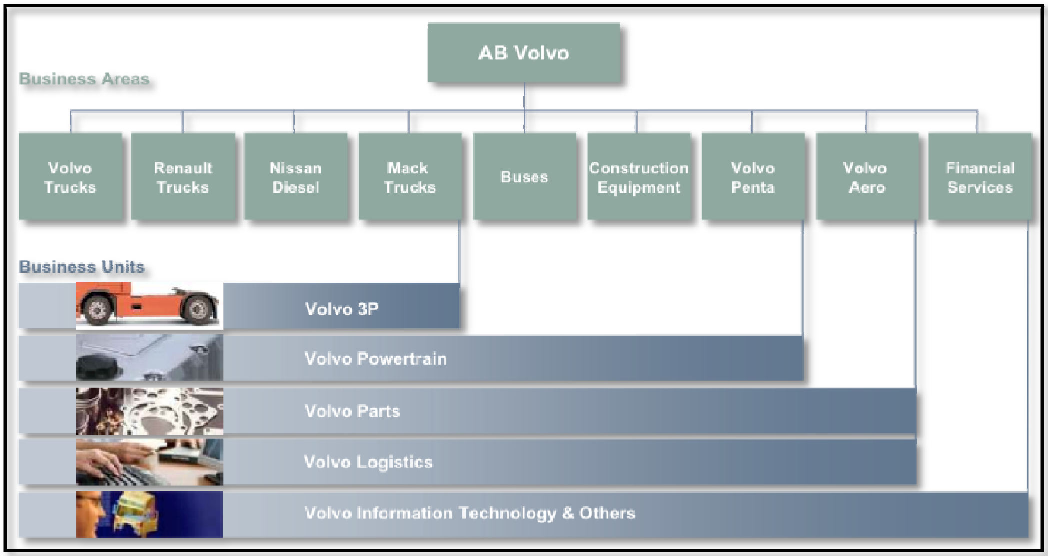

Figure 1-1: The Volvo Group (AB Volvo 2009)

1.3.2 Volvo Logistics Corporation

Volvo Logistics Corporation (VLC) is a business unit within the Volvo Group, acting as the lead logistics provider for the Volvo Group companies. Its mission is to deliver complete, value adding, supply chain solutions for its customers in the automotive, commercial transport, and aviation industries. Its major customers include Volvo Cars Corporation, General Motors Corporation, Land Rover, Jaguar, Aston Martin, Boeing, and the nine Volvo Group business areas (AB Volvo 2007).

VLC focuses on developing functional and cost-effective logistic solutions in close cooperation with its valued customers. Its philosophy is to continuously develop collaborative services, systems, and frameworks so they can offer their customers specifically tailored solutions for their logistics challenges.

VLC's logistics service offering is divided into three Global Business Operations (GBO):

(i) Inbound (material supply)
(ii) Outbound (distribution)
(iii) Emballage (packaging materials)

As illustrated in Figure 1-2, a series of business functions exist at VLC to provide each of these GBO's with information and support services (AB Volvo 2007).

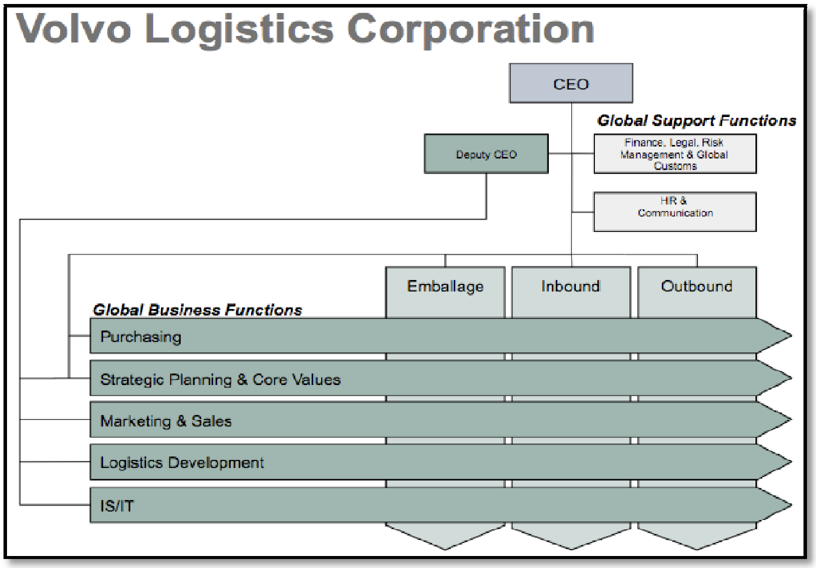

Figure 1-2: VLC Corporate Structure (AB Volvo 2007)

1.3.3 Environmental Care at Volvo Logistics

As one of the world's leading logistics service providers and a member of the Volvo Group, VLC has three Core Values: Quality, Safety, and Environmental Care. VLC understands that they have a responsibility to account for and take action to reduce the environmental impact of their logistics services.

This is a responsibility shared by the entire Volvo Group, "Environmental issues are one of our top-priorities and – backed by our resources and expertise – we can and will be part of the solution." – Leif Johansson, CEO AB Volvo. This responsibility is reflected in the Volvo Group Environmental Policy, and the Volvo $C0_2$ Challenge[1], displayed in Appendix 1 and 2 respectively.

1.3.4 Volvo Logistics Carrier Requirements and Key Performance Indicators

VLC is a non-asset based 3rd party logistics provider (3PL), meaning it purchases all of its transport services from external transport companies, hereby referred to as carriers. A large and diverse carrier network improves VLC's competitive position (Bergström

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[1] The $C0_2$ challenge is a corporate wide initiative to reduce CO_2 emissions from road transports in Europe to 50% of the 2006 baseline levels by 2020.

2009) and therefore, VLC has established service contracts with over 300 European carriers.

For a company to qualify as a VLC transport carrier they must comply with service requirements related to four key performance indicators (KPIs) (Volvo Logisitcs 2009):

(i) Pick-up precision
(ii) Delivery precision
(iii) Damage-free delivery
(iv) Deviation reporting (cost and lead time)

These carrier KPIs are measured through periodic internal performance audits and external customer feedback (Erkfeldt 2009). Exhibit 1-1 displays additional safety and environmental requirements placed on carriers in line with Volvo Logistics' ISO 14001 Environmental Management System (EMS) certification.[2]

Exhibit 1-1: Volvo Logistics Safety and Environmental Requirements for Carriers (ISO 14001)

General Requirements

- CO_2 target implemented with action plan and follow up system
- Minimum Environmental Management System requirements according to matrix/table

Road Requirements

- Minimum engine (Euro and US class) requirements for road transport according to matrix/table below
- All drivers educated in "fuel efficient driving" by 2010

Sea Requirements

- VLC requires fulfillment of EU Directive 1999/32/EC and MARPOL 73/78 Annex VI for maximum sulfur content in bunker fuel for sea transports

Euro/US engine class requirements for Europe, US, and South America:

Year	Europe	US	South Am
2007	Euro 2	US 98	-
2009	Euro 3	US 04	Euro 2
2012	Euro 4	US 07	Euro 3
2015	Euro 5	US 10	Euro 4

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[2] Please refer to section 4.4 in Chapter 4: Contextual Framework for more on the ISO 14001 EMS certification.

1.4 Research Questions

As academic researchers working in close collaboration with Volvo Logistics, the authors derived the following research question from the challenge facing VLC:

How can we develop a system that will quantify, record, analyze, and report emission levels from inbound logistics operations for logistics network management and emissions accounting?

Five interdisciplinary questions were then formulated, which provide the foundation for the solution:

1. How can we quantify emissions?
2. How can we record and store emissions data?
3. How can we properly analyze this data to extract valuable information?
4. How can we effectively communicate results internally and externally?
5. What organizational transformations need to occur in order to ensure lasting efficacy?

1.5 Problem Discussion

Volvo Logistics operates in a dynamic business environment, in which new customer demands for environmental impact assessments (EIAs) have arisen and new elements to the VLC business strategy have emerged. These include strengthening the brand image by promoting environmental care, and offering EIAs to customers as a value adding, revenue generating service. Additionally, the ability to quantify, record, analyze, and communicate emission levels will help strengthen VLC's competitive service offering against other logistics service providers, and position the company favorably in the midst of current and future environmental legislation (Hambeson 2009).

The changing business environment has led to new demands for EIAs that VLC does not currently have the capability to fulfill. As explained in the Conceptual Framework in Chapter 3, this thesis analyzes this problem in relation to three critical elements of organizational structure: people, processes, and technology.

1.5.1 Volvo Logistics Environmental Impact Assessments and Inbound Logistics Operations

Environmental Impact Assessment (EIA)

Environmental Impact Assessments (EIA) are performed at Volvo Logistics to measure and account for emissions of Carbon Dioxide ($C0_2$), Nitrogen Oxides (NO_x), Sulphur Oxides (SO_x), and Particulate Matter (PM). As illustrated in Figure 1-3, these assessments are performed for two reasons and by two different departments:

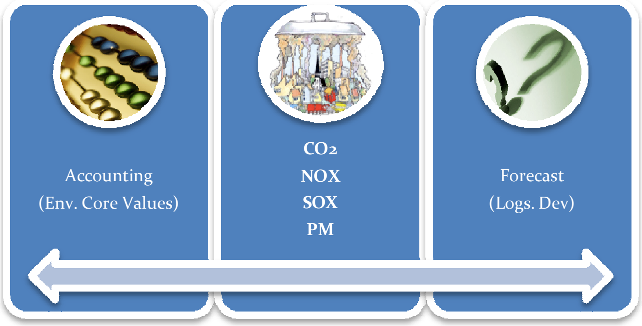


Figure 1-3: Environmental Impact Assessments at Volvo Logistics

1. Forecast emissions during the logistics network design process; performed by the Inbound Logistics Development (ILD) department.

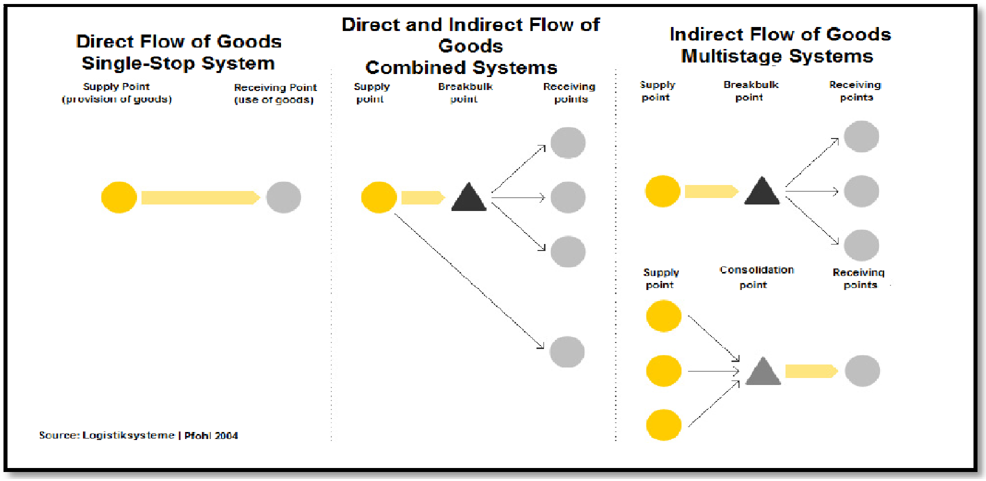
2. Account for produced emissions from transport work previously conducted; performed by the Core Values department. Volvo Logistics has provided emissions reports for its customers since 2004. The company began producing these reports exclusively for Volvo Trucks Corporation (VTC); however, they now market these reports as a value adding service for other customers. These reports are produced and presented to the customer by the Core Values department.

Inbound Logistics

Inbound logistics involves all activities associated with the receiving, storing, and movement of goods and information from suppliers to production facilities (Wu & Dunn1994). A trade-off companies must consider is whether or not inbound shipments should be consolidated. Although consolidation improves vehicle efficiency, which is good from an environmental and financial standpoint, it also means longer lead-times and thus, is not favorable from a customer service point of view (McKinnon, Stirling, and Kirkhope 1993).

Volvo Logistics has two main European offices for inbound logistics operations. They are located in Gothenburg, Sweden, and Ghent, Belgium. The Gothenburg office handles all inbound shipments traveling to locations in Sweden, whereas, the Ghent office handles all shipments to locations in Belgium.

VLC's inbound operations work primarily with two types of freight flows, Full Truckload (FTL) and Less-than Truckload (LTL) (Volvo Logisitcs 2009). FTL flows travel directly from supplier to customer on a single trailer with no cross-docking or consolidation activities. On the other hand, LTL flows are comprised of an organized transport schedule involving multiple shippers, in which smaller shipments are picked up along a pre-determined route or delivered to a consolidation terminal. They are then consolidated into a single trailer for the line-haul portion of the transport network. Upon arrival at the destination terminal, the consolidated shipments are separated and sent out for final delivery. LTL transport networks serve to increase transport equipment productivity and therefore reduce costs for all shippers involved in the network (see Figure 1-4).



Source: Logistiksysteme | Pfohl 2004

Figure 1-4: FTL (Single Stop System) and LTL (Multistage Systems) Freight Flows (DHL Logistics 2009)

1.6 Scope and Delimitations

This thesis proposes an IS/IT solution to be used exlusively for Volvo Logistics' European inbound logistics network. As a result, this case study focuses soley on the departments and functions related to VLC's European inbound operations.

Due to time and resource constraints, this thesis has a limited scope and does not cover the financial implications of the proposed solution, nor does it delve into organizational behaviour and decision making theories. Additionally, the solution is proposed from a tactical and strategic point of view. In doing so, the authors mapped out and designed the fundamentals behind VLC's required IS/IT solution, but do not go into detail regarding the specific technical issues relating to the required IT support (i.e. computer programming, network administration, and IT implementation).

In relation to the scope of Volvo Logistics' Environmental Impact Assessments, limitations have been set for the IS/IT solution to measure and report emissions of $C0_2$, NO_x, SO_x, and PM.

Lastly, the proposed emissions analysis methodology for road transportation meets the Network for Transport and the Environment (NTM) accuracy level three, while the rail and sea emissions analysis will be limited to accuracy level one (See NTM section in Chapter 4).

“All truths are easy to understand once they are discovered; the point is to discover them.”
— Galileo Galilei

Chapter 2:

Research Methodology

The research methodology illustrated in this chapter, was designed in order to fulfill the scientific research requirements put forth by the scientific community. Subsequently, empirical data was gathered and analyzed from primary and secondary sources in a systematic and objective manner and was thereby used to fulfill the thesis objective.

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2.1 The Case Study

This thesis followed a qualitative case study methodology. This case study was conducted in close collaboration with Volvo Logistics and involved exploratory, descriptive, and explanatory research (Yin 1994). Case studies emphasize detailed contextual analysis of a limited number of events or conditions and their subsequent relationships (Yin 1993). Yin (1994) defines the case study methodology as an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used.

The Case Study Validation

The application of the case study method in this thesis allowed the authors to explore (exploratory case study), describe (descriptive case study), and explain (explanatory case study) the challenge confronting Volvo Logistics. In doing so, the authors were able to extrapolate a research problem and analyze it using scientific methods. Moreover, the author's case specific consultations with external software developers and internal VLC management regarding the feasibility of proposed process and structural changes enabled the development of a practical and feasible solution. Due to the fact that this study is based on qualitative research, and does not delve into quantitative statistical analysis, the authors believe that the qualitative case study approach was the most suitable research method to employ.

Some researchers argue that because a single case study focuses on such a narrow field, the results cannot be generalized and applied to the population as a whole (Somekh and Lewin 2005). Hamel et al. (1993) rejects these criticisms and states that an individual case is the mandatory intermediary in attempting to grasp the common nature of individual actions and behaviors.

2.2 Qualitative Research

Qualitative research methods were developed in the social sciences to enable researchers to study social and cultural phenomena. Qualitative data sources include participant observation, interviews and questionnaires, documents and texts, and the researcher's impressions and reactions (Myers 2009). Qualitative research studies involve a limited participant pool in comparison to quantitative statistical research. Nevertheless, the contact with participants is often continuous and long lasting (Dawson 2007). According to Jankowicz, the most useful methods and techniques for a given research project depend on the specific nature of the research problem and its purpose (Jankowicz 1991). Due to the nature of this thesis study, qualitative research was best suited, since the primary information gathered was non-numerical and our research involved the in-depth and extensive participation of a limited participant pool.

2.3 Collaborative Practice Research

In addition to the case study, the authors utilized Collaborative Practice Research (CPR) in working with Volvo Logistics. CPR is a research technique in which the researcher is immerged in the work environment of the practitioners, and where a close collaboration develops between industrial work and academic research. Thus, paving the way for the development of both organizational and academic knowledge (Rosenhead & Mingers 2001). Such collaboration facilitates the two-fold aim of CPR: (i) to improve practice and enhance business relevancy, and (ii) to preserve the values of scientific rigor (Holmqvist 2007) thus, maintaining process uniformity, integrity and credibility throughout the research process. Mathiassen (2002) also argues that collaborative practice research is a practical way to strike a useful balance between relevance and rigor.

Collaborative Practice Research Validation

There are clear gains from the collaboration and interaction between researchers and practitioners (Holmqvist 2007). As Mathiassen (2000) states,

> *"...involved activities presuppose each other: we reach a deeper understanding of practice as we attempt to change it; we need to understand practice to design useful propositions; and the propositions and our interpretations of practice are ultimately tested through attempts to improve practice."*

In support of Mathiassen (2000), the authors believe that CPR produces valuable and unique insights, which are not possible to acquire through survey studies or scheduled interviews.

2.4 Empirical Data

The qualitative empirical data for this thesis study was collected from a wide array of primary and secondary sources.

Primary data

Primary data is raw data collected by the researcher pertaining to the specific study or research project (Hair et al. 2006). The data researchers should collect depends upon the research problem (Ghauri and Grönhauge 2002). The primary data sources utilized in this thesis along with a brief explanation are illustrated in Table 2-1.

Primary Data Sources	Explanation
Semi-structured Interviews	Fully recorded and documented interviews with practitioners and academics
Direct Involvement	Participated in real working environment at VLC and Proxio
Informal Talks	Dialogue and informal conversations held throughout the research process, often leading to specific comments in the research diary
Meeting Notes	Informal notes from discussions and observations during meetings
Research Diary	Continuous diary of activities, reflections, and notes taken throughout the research process
Minutes of Meeting	Formal minutes and documents on issues, considerations, decisions, and results

Table 2-1: Primary Sources of Data

Interviews were of particular importance to the collection of primary data. Interviewing is a technique aimed at collecting data that reflects the conscious or un-conscious mind-set of interviewees, hereby referred to as informants (Gustavsson 2009). Informants can contribute openly to the subject at hand, and all elements of the conversation have a certain value because they either refer directly or indirectly to analytical elements of the research question (Thiétart et al. 2001). Ghauri and Grönhauge (2002) continue this discussion in saying that interviews have the potential to provide an accurate and clear picture of a respondent's position on the subject than any other form of research.

With this in mind, the authors conducted nineteen semi-structured, face-to-face interviews with various informants throughout the course of this thesis. These informants held key positions at Volvo Logistics, AB Proxio, and within the academic community. Their input was essential in the exploratory, descriptive, and explanatory stages of the case study. Please refer to Appendix 3 for a list of the interviewees as well as the date and a brief description of each interview.

Secondary Data

Secondary data is data collected by other researchers or organizations (Ghauri and Grönhauge 2002). Among the secondary sources used in this study were Volvo Logistics' intranet portal, PhD. dissertations and previous thesis studies, as well as trade journals and academic publications. These sources were selected based on relevancy in regards to subject matter and recent date of publication. The secondary data sources utilized in this thesis along with a brief explanation are illustrated in Table 2-2.

Secondary Data Sources	Explanation
Volvo Intranet	Corporate policy, projects, processes and documentation
PhD. Dissertations and Previous Thesis Studies	Theories, exploratory research, and research contribution
Trade Journals and Academic Publications	Literature review on industry trends and activity related to the research objective

Table 2-2: Secondary Sources of Data

2.5 Validity and Reliability

When collecting data from primary and secondary sources, one must first ensure the sources are valid and reliable. This is of critical importance because quality data is a core element to any credible research study (Boyle, Sokol, & Johnsen 2009).

According to Yin (1994), reliability is concerned with the degree to which a specific method of research and specific collection of data would yield the same results if other researchers would conduct the same study using the same data. Validity on the other hand, refers to the capacity of research techniques to encapsulate the characteristics of the concepts being studied, and to properly measure what the methods were actually intended to measure (Payne 2004).

With this in mind, thorough consultation of all secondary data used in this thesis study was performed to ensure the data came from credible sources. The authors obtained the majority of the secondary sources from the University of Gothenburg's electronic databases Gunda and Gupea, as well as the Chalmers Technical University library, in addition to Linköping University and Lund University.

Primary data was collected from credible individuals in the academic community, as well as Volvo Logistics managers and other logistics industry professionals with years of work experience in their respective fields. Collaboration with these individuals was in a strictly professional environment so as to avoid interview bias that could jeopardize the quality of the data.

Part 2

Research & Analysis

Part 2 consists of four chapters pertaining to the research and analysis conducted in this thesis. Chapter 3: Conceptual Framework, introduces the lean systems concept applied to people, processes, and technology at Volvo Logistics. Chapter 4: Contextual Framework, presents the research conducted on current trends and challenges in the field of logistics management, information technology, and environmental science, which are relevant to the research problem. Chapter 5: Empirical Framework, presents the empirical data collected throughout the case study at Volvo Logistics. Chapter 6: Empirical Analysis, analyzes this data in relation to people, processes, and technology in order to uncover the root causes of the problem and formulate a solution.

"It is not because things are difficult that we don't dare; it is because we don't dare that they are difficult."

— Seneca

Chapter 3:

Conceptual Framework

The conceptual framework behind this thesis is derived from lean systems thinking which the authors have applied to the development of people, processes, and technology at Volvo Logistics.

Chapter Outline

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3.1 Formulating the Conceptual Framework

At the start of any research study, the researcher must first consider the relevant theories behind the research topic. This thesis however, began with an exploratory case study in which there was no clearly defined problem or theoretical foundation. The root causes of the business problem at Volvo Logistics had to first be discovered before they could be addressed. As a result, a conceptual framework, as opposed to a theoretical framework, was employed to guide the research process and formulate a solution. The authors elected to employ the lean systems concept to guide this study for two reasons:

(i) To remain grounded throughout the research process in order to collect quality empirical data and prevent the onset of information overload.

(ii) To uphold a scientific focus during the empirical analysis, in order to develop a practical solution for VLC and fulfill the requirements of the academic community.

3.2 The Lean Systems Concept

The conceptual framework behind this thesis is derived from lean systems thinking, which the authors have applied to the development of people, processes, and technology at Volvo Logistics. Lean systems thinking originated in the post WWII Japanese manufacturing industry, however, the term ‘lean’ was first coined by John Krafcik in a 1988 article titled, "Triumph of the Lean Production System," published in the Sloan Management Review (Krafcik 1988).

The concept of lean systems is about removing waste, and increasing customer value. In other words, lean systems are designed to create “more value with less work” (Womack and Jones 1994).

3.2.1 The Fundamental Principles of Lean Systems

As illustrated in the following diagram, lean systems are comprised of five fundamental principles:

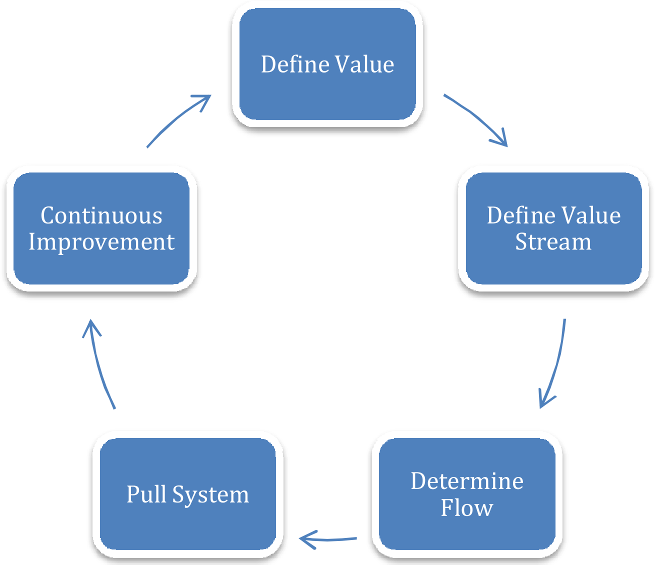

Figure 3-1: The Fundamental Principles of Lean Systems

1. *Define Value*

The critical starting point for lean systems thinking is defining value. Companies need to clearly define what their value objective is, in order to devise a lean system to obtain it (Womack & Jones 1994).

2. *Define Value Stream*

The next step is to define the value stream. The value stream is a sequential process of actions and measures required to obtain the value objective (Bicheno 2004).

3. *Determine Flow*

The third step is to determine the value flow. This refers to the development of a continuous flow of products or processes throughout the value stream in order to eliminate waiting time, machine downtime, and waste (Bicheno 2004). Although this refers mainly to production, administrative processes and services also benefit from the continuous flow of data and information. Developing a continuous flow is often aided by the implementation of new processes and technologies.

4. Pull System

In a manufacturing environment, lean systems are about letting customer demand 'pull' production. Lean production lines are designed to remain flexible, scalable, and agile in order to respond to customers' fluctuating demand without stocking up on finished goods. In regards to IS/IT, customer pull refers to variations in demand for information (Holmqvist 2007). In order to meet these demands, IS/IT systems require the development of people, processes, and technology to collect, analyze, and effectively communicate information in a timely and efficient manner (Swank 2003).

5. Continuous Improvement

The final component of lean systems is continuous improvement. Organizations implementing the lean systems concept must consider improvement as an endless pursuit of perfection. Perfection means producing exactly what the customer wants, for the right price, at precisely the right time, and with minimum defects (Bicheno 2004). Continuous improvement was popularized by W. Edwards Deming in the second half of the twentieth century and is scientifically modeled in the four-step process known as the Deming Wheel Cycle or PDSA (Plan, Do, Study, Act) (Deming 1989).

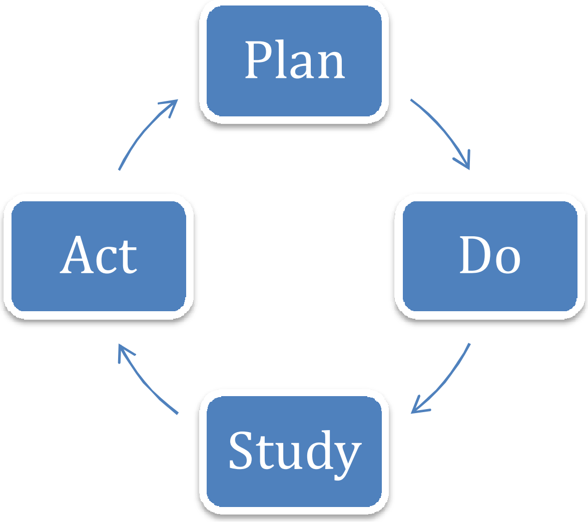

Figure 3-2: The Deming Wheel Cycle (Deming 1989)

3.3 Lean Systems Development Applied to Volvo Logistics

Although the term 'lean' was originally associated with industrial manufacturing, the lean concept can be applied to improve all functions within an organization (Swank 2003). Like their production line counterparts, lean IS/IT systems are designed to remain flexible, scalable, and agile to facilitate sudden variations in demand for information. This capability requires the development of people, processes, and technology in order to collect, analyze, and effectively communicate information in a timely and efficient manner (Swank 2003).

Therefore, the authors applied the lean systems concept to the case study at Volvo Logistics in order to facilitate the effective and efficient development of an IS/IT system as illustrated in Figure 3-3. The strategic objective of this system is to quantify, analyze and report emissions levels to decision makers in a timely and effective manner, in order to incorporate environmental impacts as a key performance indicator in logistics network management.

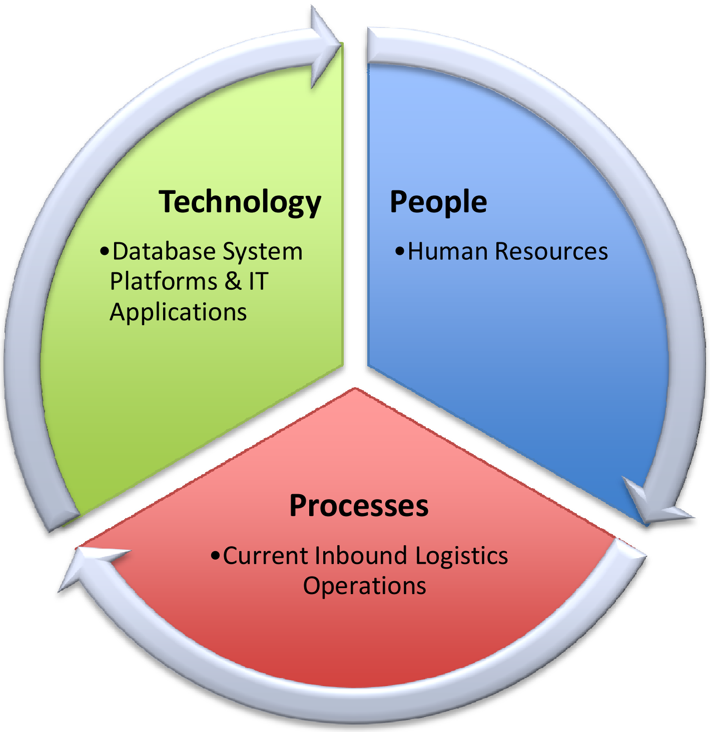

Figure 3-3: Lean Systems Development at VLC

“Economic advance is not the same thing as human progress.”

— John Clapham

Chapter 4:

Contextual Framework

This chapter presents the contextual framework behind this thesis. The information presented was collected through primary and secondary sources from both academic and industry practitioners. Each component of the contextual framework was researched in order to formulate scientific knowledge of the theory and concepts behind the research problem. This knowledge was then applied to answer the research questions and fulfill the research objective.

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4.1 Logistics Industry Trends

On a global scale, total freight transport activity has increased significantly over the last half century. Figure 4-1 illustrates this trend in the EU-27, in which total freight transport work is divided into different modes. The transport work, measured in ton-km, has increased dramatically for road and short-sea shipping. Rail transport has increased slightly, while other modes have been rather stable since 1995.

Within the transport sector, total freight ton-km are expected to grow at 2.5% annually between 2000 and 2030 by comparison with a 1.6% annual increase in passenger-km (GHG Protocol 2009). The projected increase in freight traffic is partly a function of the expansion of production and consumption, but is also reinforced by an extension of the average distance that each unit of freight travels. Globalization is lengthening supply chains, thereby increasing the intensity of freight transport in the world economy (McKinnon 2008). It is interesting to note that in some countries, Sweden for example, the actual volume of goods transport (tons), has actually decreased over the past few years, however, there has been an increase in the number of ton-km due to longer distances (Swedish Road Administration 2009). The trend towards centralization of services, distribution and retail developments, together with less dense housing provisions, have also contributed towards an increasing demand for transportation (Commission for Integrated Transport 2007).

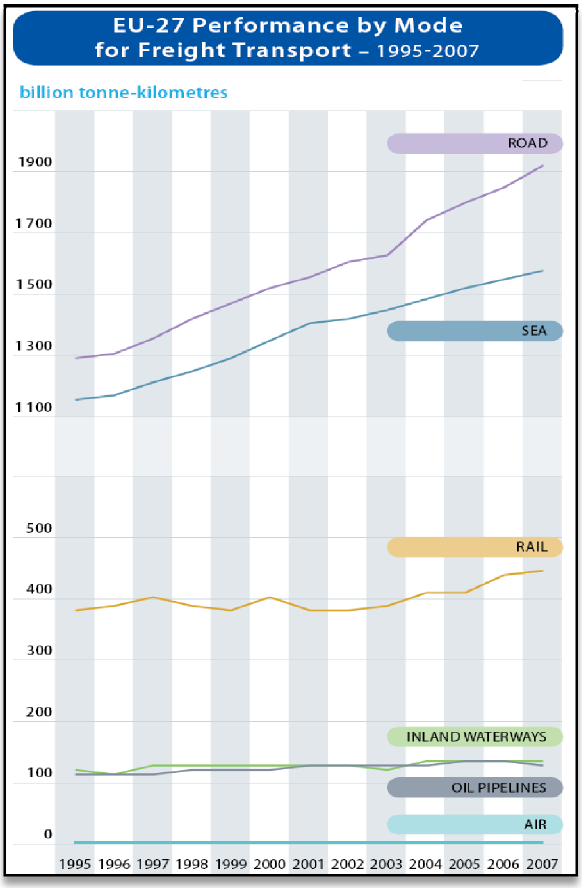

Figure 4-1: EU-27 Performance by Mode for Freight Transport (1995-2007)

4.2 Logistics and the Environment

Before discussing the environmental concerns of the logistics industry, it is necessary to first define the term 'environment' as there are several definitions. A comprehensive definition is presented in the framework of the ISO 14001 Environmental Management System, and is also the definition the authors elect to use in this thesis. "Surroundings in which an organization operates, including air, water, land, natural resources, flora, fauna, humans, and their interrelations. NOTE – Surroundings in this context extend from within an organization to the global system" (Cascio et al. 1996). The Longman Environmental

Dictionary defines environment as, “The sum total of external influences acting on an organism” (Lawrence 1998). In the same dictionary, the definition of ‘environmental impact’ offers further clarification, “The changes in total environment both in terms of the ecology and the social impact, caused by human activities” (Lawrence 1998), whereas the term ‘environmental science’ is, “the study of how humans and other species interact with their non-living and living environments.”

Despite the definition one applies to the term ‘environment’, in today’s transport sector, environmental considerations are often regarded as secondary criteria in tactical and operational planning (Abukhader and Jonson 2004). However, internal and external market demands to reduce emissions are slowly changing this notion.

McKinnon and Woodburn (1993) claim that logistics managers generally have very little influence reducing emissions because the actual amount of emissions produced on an operational level is a product of the logistics network structure, suggesting a disconnect between operations and management. McKinnon (2008) suggests, the greening of a firm’s logistics operations at a fundamental level will require nothing short of a change in management culture and strategic priorities.

4.2.1 Carbon Dioxide Emissions from Transport

In 2004, transport accounted for 23% of man-made CO_2 emissions, suggesting that freight transport was responsible for approximately one third or 8% of CO_2 emissions (IPCC 2007). Transport emissions are produced from the use of motorized vehicles powered by fossil fuels (i.e. petrol, diesel, natural gas or electricity generated from fossil fuels). Furthermore, emissions from the transport sector have increased by 8% in the past fifteen years (European Commission 2009).

From a European Union perspective, the transport sector is the only economic sector in which emissions of CO_2 have increased over this period as shown in Figure 4-2. Moreover, the transport sector is the main contributing source of CO_2 emissions and the fact that these emissions are increasing rather than contracting is a cause for great concern.

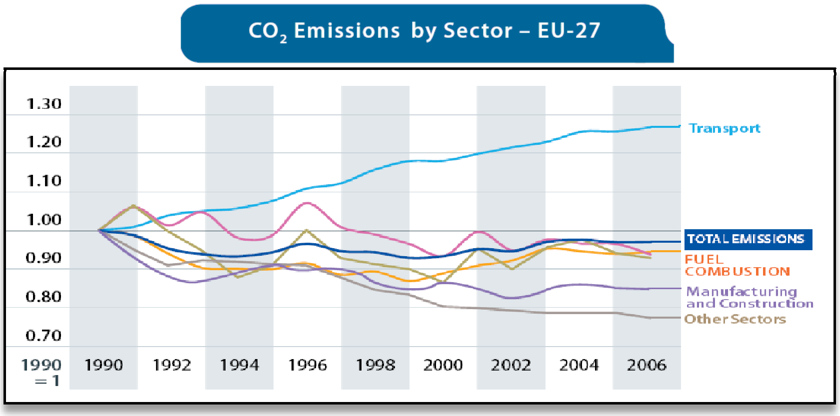

Figure 4-2: CO_2 Emissions by Sector EU-27 (European Commission 2009)

4.2.2 Climate Change Implications for Logistics Service Providers

In light of the threat posed by climate change and continued environmental degradation, preserving the environment while maintaining economic prosperity has become a top priority of our time. We now see governments, businesses, and concerned citizens taking serious action to work together to address environmental issues (Suzuki 2004). According to Wu and Dunn (1994), to achieve business goals and objectives, a company must respond to increasing consumer demand for 'green' products, comply with ever tightening environmental regulations, and implement environmentally responsible plans as a good corporate citizen.

Companies are now turning to their logistics service providers (LSPs) to help them not only reduce costs, but to also reduce the environmental impact of their logistics activities and monitor progress towards corporate and legislated emission reduction targets. This has placed higher demands on LSPs to develop lower impact logistics solutions and develop innovative systems and models that quantify and present accurate and timely environmental performance reports (Supply Chain and Logisitcs Association of Canada 2008).

McKinnon (2007) suggests that the greening of a firms' logistics system requires nothing short of a change in management culture and strategic priorities shared by all stakeholders i.e. shippers, carriers, and third party logistics providers (3PLs). Furthermore, Wu and Dunn (1994) state that in order for logistics systems to become environmentally responsible, the traditional view of minimizing costs and maximizing profits needs to be accompanied by a new objective. Namely, to optimize logistics network performance for a 'triple bottom line'; cost, environment and people (Wu & Dunn 1994).

4.2.3 Emissions Reduction in the Logistics Industry

Blinge and Lumsden (1996) propose that measures to help offset the environmental impact of freight transport can be classified as internally and externally related initiatives. Internal initiatives are related to advances in the field of vehicle design, engine design, transport infrastructure, fuel types etc. External initiatives are related to the logistics operations in the company, such as consolidation and packaging. Please refer to Appendix 4 for an illustration of a number of these internal and external initiatives related to the road transport sector.

According to McKinnon (1994), emission levels from road transport are based on four critical ratios:

1. Volume of emissions : road vehicle kilometers
2. Road vehicle kilometers : road ton kilometers
3. Road ton kilometers : total ton kilometers (modal split)
4. Total ton kilometers : Gross Domestic Product (GDP)

McKinnon argues that addressing these four ratios is paramount to a successful emissions reduction strategy. It is important to note however, that according to transportation growth forecasts presented by the European Commission (2009), the growth of freight transport as measured in ton-km, will more than offset environmentally-favorable trends in these ratios. According to Tim Lynch, the American Trucking Association's Senior Vice President, the only effective means to realistically minimize ton-km and thereby cap the increase of emissions from road transport, is by increasing truck equipment productivity (Logistics Management 2009).

4.2.4 Other Emissions from Transport

In addition to $C0_2$, the most common emissions produced from fossil fuel powered transportation are Nitrogen Oxides, Sulphur Oxides, and Particulate Matter; all of which can be transported by wind over long distances and deposited far from the point of origin. Consequently, these gasses have acute and chronic health effects. Acute refers to the effects that act immediately on a specific target organ or point of entry into the body. These points of entry are typically the eyes and the lungs, as they are in immediate contact with the ambient air. On the other hand, chronic effects are those that affect the body in reference to the time of exposure (Griffin 2007).

Nitrogen Oxides (NO_x)

NOx causes a wide variety of environmental and health problems. One of the effects of NOx is ground-level ozone, which is formed when NOx and volatile organic compounds (VOCs) react in the presence of sunlight. When NOx reacts with other substances in the air, it forms acids which then fall to earth as rain, fog, snow or dry particles. The increased nitrogen loading in water bodies, particularly coastal estuaries, upsets the chemical balance of nutrients used by aquatic plants and animals. Additional nitrogen in the environment accelerates eutrophication, leading to oxygen depletion and therefore, reduces fish and shellfish populations. Additionally, NOx reacts with ammonia, moisture, and other compounds to form nitric acid and related particles that affect the respiratory system, damage lung tissue, and can cause premature death (US EPA 2009).

Sulphur Oxides (SO_x)

SO_x, like nitrogen oxides, reacts with other substances in the air to form destructive acids. These acids damage forests and crops, change the composition of soil, and turn lakes and streams into an acidic and uninhabitable environment for fish and other aquatic life. This continued exposure over a long period of time also changes the natural variety of flora and fauna (US EPA 2009). At peak levels, SO_x can cause temporary breathing difficulty for people with asthma who are active in the outdoors. Long-term exposure to high levels of SO_x can cause respiratory illness and aggravate existing heart disease (European Environmental Agency 2008).

Particle Matter (PM)

PM pollution contains microscopic solids or liquid droplets that are so miniscule that they can enter human airways and cause serious health problems. Numerous scientific studies have linked PM exposure to increased respiratory problems such as irritation of the airways, coughing, difficulty breathing, decreased lung function, aggravated asthma, development of chronic bronchitis, irregular heartbeat, heart attacks, and premature death in people with heart or lung disease. Children and older adults are most likely to be affected by exposure to PM pollution (US EPA 2009). It has been estimated that the presence of $PM_{2.5}$ in the air, otherwise known as fine particulate matter, has reduced statistical life expectancy in the EU by more than eight months (EEA 2009).

4.3 Environmental Legislation for Transport

Integrating environmental concerns into political legislation is a current topic of discussion in the international arena. The European Union has expressed its commitment to cut greenhouse gas emissions by 20% by 2020, and has promised to lead international negotiations to adopt even more ambitious targets. In line with this commitment, the EU has legislated a European strategy for sustainable transportation systems which define objectives for integrating environmental requirements into the transport sector.

This EU strategy aims to ensure that member states take environmental concerns into account when drafting and implementing transport policy. This strategy recognizes the positive results of certain measures already taken at the EU level, but underlines that further progress is required in the following areas:

- Avoidance and / or elimination of the negative effects of traffic growth, particularly through land use measures and infrastructure development.
- Promotion of public, intermodal, and combined transportation, as well as more environmentally friendly modes (e.g. railways and inland waterway).
- Further research and technological development, to reduce emissions and noise.
- Raising awareness among the public, vehicle operators, and the logistics and transport industry as a whole, on how to reduce the environmental impact of transportation through KPIs and environmental education.

The EU strategy calls on member states to implement these measures at the national level and enforce them within the operations of international organizations. The Swedish government has proposed a 25% reduction of GHG from 1990 levels by 2020 and has stated its firm support for the EU's target of at least a 20% reduction (European Environmental Agency 2008). Sweden's strategy for reducing emissions is applied to the transport sector in the following areas: promote a more transport efficient society, conduct energy efficient road maintenance, increase eco-driving training, and increase the number of energy efficient vehicles in operation. In addition to these areas, the strategy also emphasizes long-term initiatives and international cooperation (Swedish Road Administration 2009). This strategy supports McKinnon (1994), who argues that for legislated environmental policies to be effective, they must be industry wide and implemented within a consistent framework at the international level.

In the United States, the National Environmental Policy Act (NEPA) requires federal agencies to integrate environmental values into their decision-making processes by considering the environmental impact of their proposed actions and reasonable alternatives to those actions. Under the NEPA all federal acts that are likely to have significant effects on the quality of the natural environment are required to include a detailed statement assessing the environmental impacts of such legislation.

One of the most recent pieces of US governmental legislation geared towards reducing emissions from the logistics and transport industry was published on 14 May, 2009. Titled, "The Federal Surface Transportation Policy and Planning Act of 2009," this new piece of legislation aims to increase the proportion of national freight transportation provided by non-highway or multimodal services by 10% by 2020 and reduce national surface transportation-generated carbon dioxide levels 40% by 2030 (Logistics Management 2009).

4.3.1 Private Sector Initiatives

Mitigating the environmental impact from the transportation sector is a serious challenge. In recent decades, a number of private sector initiatives have been implemented to help meet this challenge. Vehicles and engines have become more fuel-efficient, shipment consolidation has increased, and renewable fuels have been introduced (Swedish Road Administration 2009).

In order to make the transition from traditional transportation methods to carbon neutral transportation possible, additional initiatives from the private sector are required. The collaboration between various stakeholders in the transportation sector, other business and industry agents, and society as a whole, needs to intensify in order to accelerate this development (Hedenus 2008). For this reason, the Centre for Environment and Sustainability at Gothenburg University and Chalmers Institute of Technology, in addition to Preem, Schenker, Volvo Trucks, and the Swedish Road Administration, are partnering on a project titled, "On the Road to Climate Neutral Freight Transportation." The objective of this project is to show how to reduce emissions associated with freight transport by road in Sweden, and how the various stakeholders in the private sector can contribute. The collaboration focuses on improving shipping efficiency, fuel production efficiency, vehicle efficiency, as well as expanding the use of renewable fuels (Hedenus 2008). Please refer to Appendix 5 for details on research and development commitments made by each of the project partners.

4.4 Environmental Management Systems (EMS)

Environmental management can be defined as the way in which companies deal with environmental issues (Kolk 2000). Normally, environmental management is facilitated by an Environmental Management System (EMS), a tool that organizes and facilitates environmental work and tracks progress towards organizational goals (Ammenberg 2004). An EMS enables companies to demonstrate sound environmental management to stakeholders, which can lead to improved brand image and increased market opportunities (Welford 1998).

4.4.1 EMS Standards

The two main accredited EMS standards today are ISO 14001 and the EU Eco-Management and Audit Scheme (EMAS) (Ammenberg 2004). Both standards were voluntarily developed during the 1990s with the possibility of being verified by an external body. ISO 14001 is an international standard developed by industry, trade associations, governments and non-governmental organizations while EMAS is a European standard developed by the European Union.

ISO 14001 applies to all organizations in any industry, while the EMAS is primarily focused on the manufacturing and energy industry. In the past, the EMAS standard contained other specific requirements; however, in 2001 EMAS was revised and is now based on ISO 14001. The largest remaining difference between the two is that EMAS requires an environmental report, which is reviewed by an external, independent, third party (Ammenberg 2004), while ISO 14001 does not. Figure 4-3 illustrates the main components of ISO 14001.

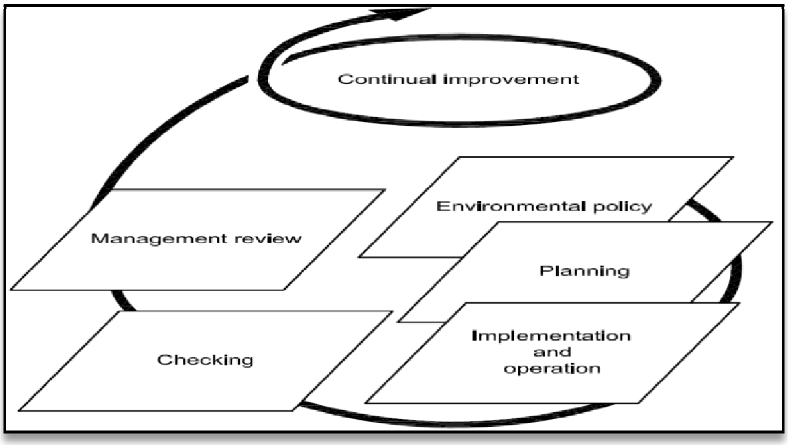

Figure 4-3: ISO 14001 Main Components (Swedish Standard Institute)

The ISO 14001 standard has two main weaknesses. First and foremost, companies can become certified simply by self-declaration. In doing so they can audit themselves, and are not obliged to make the audits public. Also, in ISO 14001 there are no registered parameters so the level of detail in the audit is left up to the auditing party's criteria (Almgren & Brorson 2003).

4.4.2 Environmental Management in Practice

There are many benefits for a company that chooses to implement an EMS (Welford 1998). For example, measures taken to reduce the company's environmental impact can also directly reduce costs, e.g. energy savings in a factory will result in lower energy expenses and increasing carrier fill rates will reduce the number of trucks on the road thus, reducing the shipper's transportation costs. There are also competitive advantages such as the benefit of staying ahead of the competition and legislation. Relationships with governmental agencies can also be improved which can lead to regulatory advantages for the firm (Kolk 2000). For example, in the EMAS standard there is a recommendation to all EU member states to facilitate the relation between EMAS registered companies and authorities. Lastly, the company can experience market benefits since the company image can be significantly improved by an EMS certification. An EMS certification is often seen as a sign of a company's commitment to environmental issues. However, in reality an EMS says very little about a company's actual performance. It is important to remember that an EMS only provides a standard at the organizational level and it does not set specific levels for emissions reductions or performance requirements. In theory, a company could set low targets with a slow improvement rate and still receive an EMS certification. On the other hand, a company could also perform well in the environmental area without having an EMS. As Ammenberg (2004) asserts, it is not possible to answer the general question as to whether an EMS actually improves environmental performance. Although an EMS certification does not necessarily decrease the company's environmental impact, it helps them achieve a better understanding of their ecological footprint. This is the first step towards a progressive change in corporate culture.

4.4.3 Emissions Performance Reporting

Performance reporting is an essential component of business operations. There are different types of reports a firm must produce ranging from legal compliance, financial disclosure, voluntary non-financial, and environmental performance. Environmental reporting is declining on a yearly basis with 'sustainability' or 'corporate responsibility' reports taking a major fraction of the total non-financial reporting activity (Baumann 2009).

Various reporting guidelines are used by companies in filing these reports, such as the Global Reporting Initiative (GRI), Carbon Disclosure project, AA1000AS and Global Compact. In addition to the variety of reporting tools, the reports also have different performance indicators and required data. It is difficult for companies to not only choose the most suitable reporting tool, but to also collect all relevant information.

4.5 Emissions Reporting Standards: GHG Protocol

Currently, the most widely used standard for measuring man-made GHG emissions is the Greenhouse Gas Protocol (GHG Protocol), an international accounting tool for government and business leaders to understand, quantify, and manage GHG (GHG Protocol 2009). The GHG Protocol currently collaborates with businesses, governments, and environmental groups around the world and serves as the basis for the ISO 14001 standard. In order to create an accurate account of their emissions, companies have found it useful to divide overall emissions into specific categories. This allows companies to use specially developed methodologies that calculate the emissions from each sector and source category (GHG Protocol 2009). Figure 4-4 outlines the five steps involved in the GHG Protocol.

Steps in Identifying and Calculating Greenhouse Gas Emissions

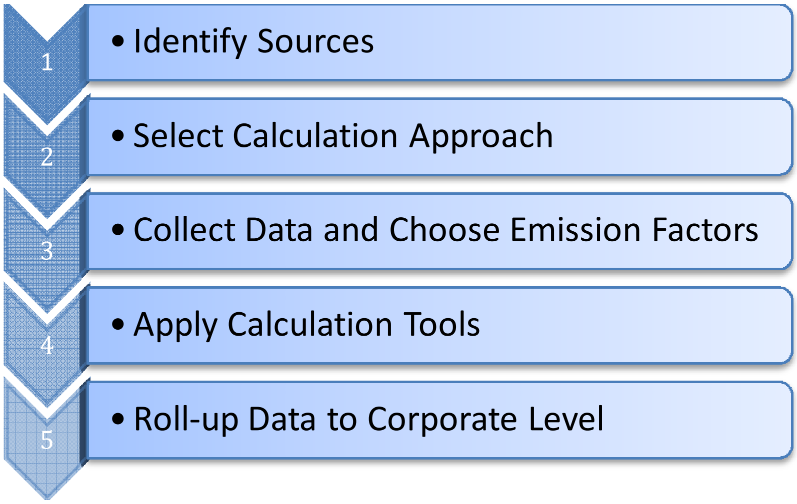

Figure 4-4: GHG Protocol Revised Edition (2007)

1. Identify Sources

The first of the five steps in identifying and calculating a company's GHG emissions as outlined in Figure 4-4, is to categorize the GHG sources within the company's boundaries. The main energy sources for mobile combustion emissions in Europe are diesel and electricity. Road and sea transport are the primary consumers of diesel fuel, while rail employs both electricity and/or diesel depending on the country. It is important to note however, that the production of some energy sources requires the use of others. For example, as shown in Figure 4-5, the amount of energy used to produce one unit of diesel is significantly lower than that required to produce one unit of electricity. This comparison is based on electricity produced from a coal-fired power plant.

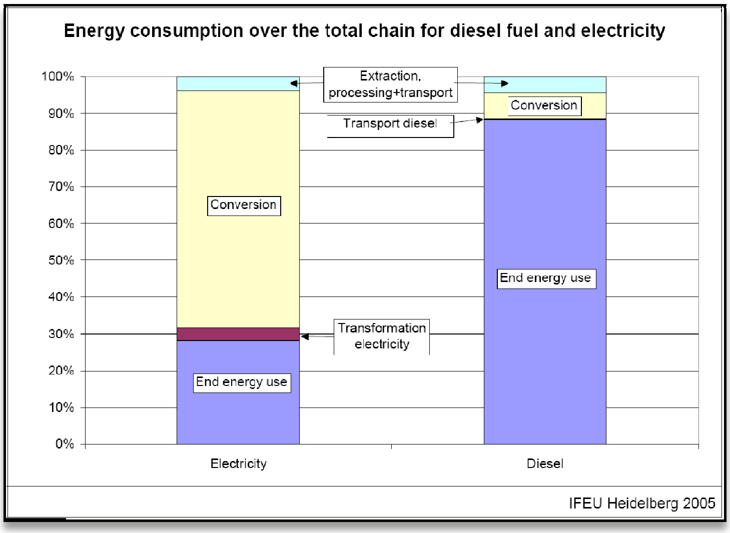

Figure 4-5: Energy Consumption Over the Total Chain for Diesel Fuel and Electricity Energy

As mentioned in Chapter 1, section 1.6, this thesis does not take into account the emissions resulting from the extraction and conversion of diesel. Instead, it focuses on the emissions produced as a result of fossil fuel powered transportation services.

2. *Select a Calculation Approach*

Direct measurement of GHG emissions by monitoring concentration and flow rate of emissions is not common practice (GHG Protocol 2009). Particularly in a transportation scenario, it is difficult and expensive to monitor the emissions of all vehicles in a fleet. With this in mind, an alternative way is to base estimated emission levels on the amount of fuel consumed. Knowing the carbon and sulfur content of the fuel consumed, in addition to the type of engine used, companies can develop standard emission profiles to be employed in calculating emissions.

3. *Collect Data and Choose Emission Factors*

The optimal way to measure emissions from transport activities is to use case specific per vehicle and per shipment data. Currently, companies can gather emissions data by directly requesting it from their transport providers; however this often results in high level, low detail data (NTM 2007). An ideal scenario to collect case specific data is to have an onboard computer capable of recording and uploading data into an environmental performance database. While this type of system is currently available, it is not universal and can be very expensive to implement (Euro FOT 2009). Additionally, many companies employ several different transportation service providers, and unless all of them are equipped with this system, it is not a valid approach.

To obtain emission profiles, companies need to collect data based on different variables that affect the performance of the transport activity. These variables are different depending on the type of transport mode employed. The reliability and validity of the gathered data is of paramount importance and whenever possible, situation specific data should be used (Swahn 2008). Exhibit 4-1 illustrates specific data fields relevant to emissions calculations for road, rail and sea transport.

It is important to note, that once these variables have been taken into account, the calculation will provide total emissions per load unit. If the load unit is full of goods belonging to just one shipper, then it is quite easy to allocate the corresponding emissions to that company. In practice however, unless dealing with FTL shipments, total emissions must be allocated to multiple shippers.

The main method for allocating emissions is based on the load factor percentage. The load factor percentage is the proportion of the total load belonging to each shipper. This becomes more complicated when mixing freight weight and volume as the payload. The question is, which volume to weight ratio should be accountable for a greater percentage of emissions: high volume-low weight or high weight-low volume? To solve this dilemma, a measure of 1 cubic meter equal to 333 kilograms is often used but it can vary according to the market and the negotiated terms between the parties involved (Palm 2009).

Road Transport

- Vehicle size and weight, vehicle configuration (trailer), motor concept, transmission
- Distance
- Weight of load (load factor)
- Driving pattern:
  - Influence of the driver: speed and/or eco-driving
  - Road category: urban/extra-urban/rural roads
  - Curves and gradient: flat, hilly, or mountainous

Rail Transport

- Traction type (diesel, electric)
- Distance
- Train length and total weight
- Proportion of load weight to empty weight of wagons and transport vessel (load factor)
- Route characteristics (gradient)
- Driving behavior (speed, acceleration) and air resistance

Sea Transport

- Fuel consumption according to type of ship:
  - General cargo, Ro-Ro vessel, Containerships
  - Bulk cargo ship
  - Tankers
- Type of fuel used:
  - Sulfur content
- Navigation speed
- Distance
- Capacity utilization (load factor)

Exhibit 4-1: Data for Mode Specific Emissions Calculations (Swahn 2008)

4. Apply Calculation Methodology: The Network for Transport and the Environment (NTM)

In Sweden, there are two leading bodies researching emission calculation methodologies: (i) the Swedish Environmental Institute Ltd. (IVL) and the Network for Transport and the Environment (NTM). In this thesis, the authors have chosen to use the methodology developed by the NTM. NTM is a non-profit organization founded in 1993, aimed at establishing a common base of values and principles on how to calculate the environmental performance for various modes of transport. NTM acts as a common and accepted method for calculating emissions from goods and passenger transport (Swahn 2008). Among the member organizations of NTM are the major Swedish industrial companies: Volvo, IKEA, AstraZeneca, SKF, ABB, and Ericsson, logistic companies: Kuehne and Nagel, Schenker AB, Green Cargo, Maersk, and DHL, universities: Lunds Universitet, Linköping Universitet, and Eindhoven University of Technology, and lastly governmental institutions: Vägverket, Västtrafik, and the Swedish National Road and Transport Research Institute.

The NTM methodology allows for the calculation of emissions based on three accuracy levels (NTM 2007):

- General Performance - Accuracy Level 1
    - This level of accuracy includes average vehicles/vessels consuming average fuel and engine/motor specifications. The allocation of emissions to individual shippers on a shared load unit is based on average load factors.

- Defined Performance - Accuracy Level 2
    - This level of accuracy includes specified average performance for vehicles/vessels with average load factors consuming average fuel and with average engine/motor specifications linked to general goods flow.

- Detailed Performance – Accuracy Level 3
    - This level of accuracy includes specified vehicles/vessels, fuel type and engine/motor specifications linking a shipment to a specified vehicle/vessel in each transport leg in a transport chain.

5. Roll-Up GHG Emissions Data to Corporate Level

The final step in the GHG Protocol is to ensure the emissions data is communicated effectively to the corporate level. This can be done in either a centralized or decentralized manner. The main difference between the two is that in the centralized manner, all of the different facilities report the data to a central corporate office where all emissions are calculated. In the decentralized manner, the data is calculated at the facility and total emissions are then reported to the corporate office.

The centralized manner has the advantage of trained personnel that can efficiently process the information however, they lack the presence on the operational level to validate the data gathering process. It is important to plan this process carefully to ensure a smooth reporting process, reduce the risk of errors that might occur while compiling data, and ensure that all facilities are collecting information on a consistent basis (GHG Protocol 2009).

4.6 Evaluating Emissions

Researchers have differing opinions on what is the most effective way to evaluate the environmental impact of emissions (Baumann 2009). The most common method is to quantify the absolute amount of emissions, in tons or kilograms, from a given activity or sector and benchmark this amount against a base year. The disadvantage with this approach is that it does not account for the fact that different pollutants have significantly different impacts (Baumann 2009). For example, one kilogram of CO_2 cannot be compared to one kilogram of PM. If an emissions report stated that 100 kg of CO_2 and 1 kg of PM where emitted, it would appear to the reader as if the amount of PM per ton-km emitted was negligible when in fact, it is otherwise.

Researchers have developed different methods of evaluating and internalizing the external costs of environmental impacts from emissions. This thesis features two approaches: (i) the application of the Environmental Load Unit (ELU) and (ii) the application of a monetary value (the IMPACT study, Section 4.6.2). The authors chose to research these two approaches in order to apply the best method to the proposed solution for VLC. The ELU was originally developed and is currently used in Sweden; while the IMPACT study is a European-wide initiative that summarizes emission evaluation studies performed by a host of other institutions.

4.6.1 Environmental Load Unit (ELU)

The Environmental Load Unit (ELU) is a unit of measurement used for quantifying the environmental impact of various air pollutants. The ELU approach was developed in the 1990’s by the Swedish Environmental Institute (IVL), in conjunction with the Chalmers University of Technology, in Gothenburg Sweden. An ELU is a unit of measurement that quantifies society’s willingness to pay avoidance and/or abatement costs of the environmental impact resulting from 1 kg of a given emission (Swerea 2009). As illustrated in Table 4-1, the bigger the impact, the greater the number of ELUs.

Air Pollutant	Unit	Index
CH_4	2,7	ELU/kg
CO	0,33	ELU/kg
CO_2	0,108	ELU/kg
PM	36	ELU/kg
N_2O	38,3	ELU/kg
NH_3	2,9	ELU/kg
NO_x (NO_2)	2,13	ELU/kg
SO_x (SO_2)	3,27	ELU/kg

Table 4-1: ELU Values for Air Pollutants (Swerea IVF, Research Institute 2009)

Applying the ELU approach to the earlier example of 100 kg of CO_2 and 1 kg of PM, would show that 100 kg of CO_2 is equal to 10.8 ELUs whereas 1 kg of PM is equal to 36 ELUs.

4.6.2 IMPACT: Applying a Monetary Value to Emissions

The second method of evaluating emissions involves allocating a monetary value to various emissions in order to internalize the external cost of the pollutant. According to the Welfare Theory approach, internalization of external costs by market-based instruments may lead to a more efficient use of infrastructure, reduce the negative side effects of transport activity, and improve the fairness between transport users (European Environmental Agency 2008). Currently, one of the most comprehensive studies on quantifying emissions in monetary terms is the Internalization Measures and Policies for All External Costs of Transport (IMPACT) study. IMPACT was commissioned by the European Commission to summarize all existing scientific knowledge on the subject, and recommend default values for estimating the external costs involved in the transport sector (Maibach 2008). The studies summarized in IMPACT are illustrated in Exhibit 4-2 on the following page.

Exhibit 4-2: Environmental External Costs Studies Summarized by the IMPACT Study

- EU-Research projects of several framework programs to estimate external costs (such as UNITE, ExternE, GRACE, etc.)
- Other EU projects on external and Infrastructure costs, particularly *Marginal costs of Infrastructure use – towards a simplified approach*, CE Delft, 2004.
- National research projects and studies on external costs (particularly for the UK, the Netherlands, Switzerland, Austria, Germany).
- International estimates of external costs (such as by UIC, ECMT).
- EU-proposals to standardize marginal cost estimation (High level group approaches).
- EU-Networking projects to discuss pricing instruments (CAPRI, IMPRINT, MC-ICAM).
- National pricing strategies (e.g. HGV charging in several countries, HGV-fee in Switzerland, urban road pricing schemes such as London and Stockholm congestion charges).
- Several studies on internalization policies at different levels (such as the mentioned strategy papers at EU-level, policy proposals at national level.

Given this background information, Table 4-2 illustrates the IMPACT study's EU-25 average values for NOx, SOx, PM and $C0_2$ emissions from transportation:

Euros/ton (EU-25 Avg. 2008)			
	NOx	***SOx***	***PM***
Euros (€)	4400	5600	26000

Euros/ton CO2 (EU-25)			
Year of application	Lower Value (€)	Central Value (€)	Upper Value (€)
2010	7	25	45
2020	17	40	70
2030	22	55	100
2040	22	70	135
2050	20	85	180

Table 4-2: Impact Study, Estimation of External Costs in the Transport Sector (IMPACT 2008)

4.7 IS/IT in Logistics

Rapid advancements in the field of Information Systems/Information Technology (IS/IT) have dramatically influenced the logistics industry in recent years (Fredholm 2006). Before the widespread acceptance of the Internet, sophisticated 3PLs used customized software for electronic data interchange (EDI) with their clients (Fredholm 2006). The emergence of web-based IT platforms has allowed 3PLs to reengineer their customers' supply chain processes by providing online collaboration and synchronization via the web.

According to the Canadian Association of Supply Chain and Logistics Management (2008), IS/IT service demands placed on 3PLs vary greatly from sector to sector. For example, pharmaceutical and chemical manufacturers are pushing for item-level traceability and supply chain visibility in order to better respond to governmental requirements such as anti-terrorism acts and food and drug regulations, as well as corporate responsibility issues such as product recall and public safety. The aerospace sector mainly emphasizes total supply chain quality ratios such as Six Sigma processes and other quality standards such as ISO standards, with less emphasis on costs. Retailers focus on reducing out of stocks and increasing visibility with their suppliers from low-cost countries. Transportation service providers also have a different focus on reducing operational costs and maximizing energy consumption with the aim of minimizing their environmental footprint (Aberdeen Group: The Supply Chain Innovator's Technology Footprint 2007).

4.7.1 IS/IT Value Proposition

IT tools can leverage the data created by the existing IT infrastructure to provide valuable additional services. Some of these services include:

- *Supply Chain Visibility:*
    - Typically both the order data and shipment data are stored in different operational systems. To provide complete supply chain visibility for the customer, the order and shipment data needs to be collected in a real-time data warehouse or an operational data store (ODS), from where seamless online tracing and tracking can be provided.

- *Forecasting and Simulation:*
    - Sophisticated logistics network design models can be created using the available inventory movement data to simulate network performance and forecast results. These forecasts can significantly help customers optimize their distribution and logistics network by significantly reducing their transportation and inventory carrying costs.

- *Customized Reports and Analyses:*
    - 3PLs can use IS/IT to capture and analyze data to produce customized reports pertaining to their customers' supply chains.

4.7.2 Logistics System Simulation Technology

Developing and testing new logistics systems in the real world is a high-risk undertaking. Many 3PLs try to minimize their risk through the use of simulation tools. Simulating logistics systems performance before implementation allows 3PLs to compare scenarios in order to determine the best solution. Simulation is not a new phenomenon however; new IT tools and increased computing power have brought new possibilities to the industry. There are many examples of logistics concerns that can be answered through the use of modern simulation tools (Supply Chain and Logisitcs Association of Canada 2008). The main concerns are as follows:

- Analyze how transport costs change with different logistic solutions, based on real shipment information and transport rates
- Calculate where production resources should be located and what is their required capacity
- Identify bottlenecks in production and distribution
- Analyze the change in costs that occur when moving one production location to another city or country
- Analyze how a changing shipment structure influences transport costs

The following quote summarizes how important IS/IT has become in the logistics industry, not only from a cost point of view but also from a customer service point of view.

> "*Customer demand for IS/IT services has increased over the past few years and the dissatisfaction rate with 3PL information services has risen. We find this dissatisfaction rate basically echoing the fact that in the supply chain information requirements have increased to the point where information is required just as much as the physical activity. And in general the 3PL industry has not invested to get ahead of the curve. So that is something that is very important to pay attention to, to know that this is going on within customer's expectations.*"
>
> – Greg Aimi, AMR Research, 2009

"All progress is precarious, and the solution to one problem brings us face to face with another problem."

— Martin Luther King Jr.

Chapter 5:

Empirical Framework

This chapter presents the empirical data collected throughout the case study at Volvo Logistics. The research methodology presented in Chapter 2 was used to guide the collection of empirical data in a systematic and objective manner to ensure the principles of scientific research were upheld. The data presented in this chapter is categorized into four sections: (i) IS/IT infrastructure (ii) IT Applications (iii) Inbound Logistics Development (iv) and Emissions Reporting.

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5.1 IS/IT Infrastructure

As a global logistics service provider, Volvo Logistics' IS/IT infrastructure is extensive and diverse. It has evolved and expanded through piecemeal application deployments and upgrades, and through mergers and acquisitions (Erkfeldt 2009). The first section of this empirical framework focuses its attention on the three database systems which facilitate VLC's inbound logistics operations in Europe: TIR, FADS, and CIC.

5.1.1 Transport Information Rutiner & Forwarding Administration System

Transport Information Rutiner (TIR) and Forwarding Administration System (FADS) are IT systems used to record shipment data for VLC's European inbound logistics networks. Data from freight flows to customer locations in Sweden and are stored in TIR, while data from freight flows to customer locations in Belgium are stored in FADS. This data is input by individuals working in shipping and receiving in VLC's terminals.

The data in each of these systems is stored in two streams; Cost (from carriers) and Billing (to customers). The cost stream audits and approves the invoices that VLC receives from its network of carriers. Once approved, these invoices proceed to the billing stream, where margins and administrative costs are applied and the customer is billed the correct amount, as shown in Figure 5-1. It is important to make the distinction between Cost and Billing, because despite what one may think, the data in each stream is often quite different (Palm 2009).

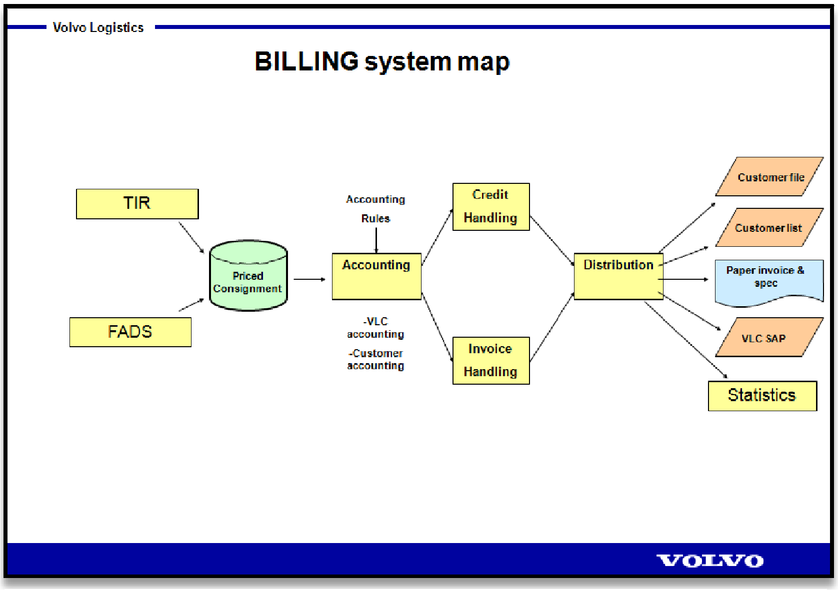

Figure 5-1: Billing System Map

5.1.2 Cost Invoice Control (CIC)

Cost Invoice Control (CIC) serves as VLC's carrier invoice auditing system. A pre-calculated cost for transport work is first obtained based on the actual shipment data (input from TIR and FADS) and the carrier tariffs. When the carrier invoices are received in the cost stream (through EDI, WEB-based invoicing or paper invoicing) they are compared with pre-calculated costs (allocation and control). If the invoiced amount is too high, then CIC will identify the error and the accounting department will begin negotiations with the carrier to come to terms on the correct invoice amount. Figure 5-2 illustrates the structure of the CIC system.

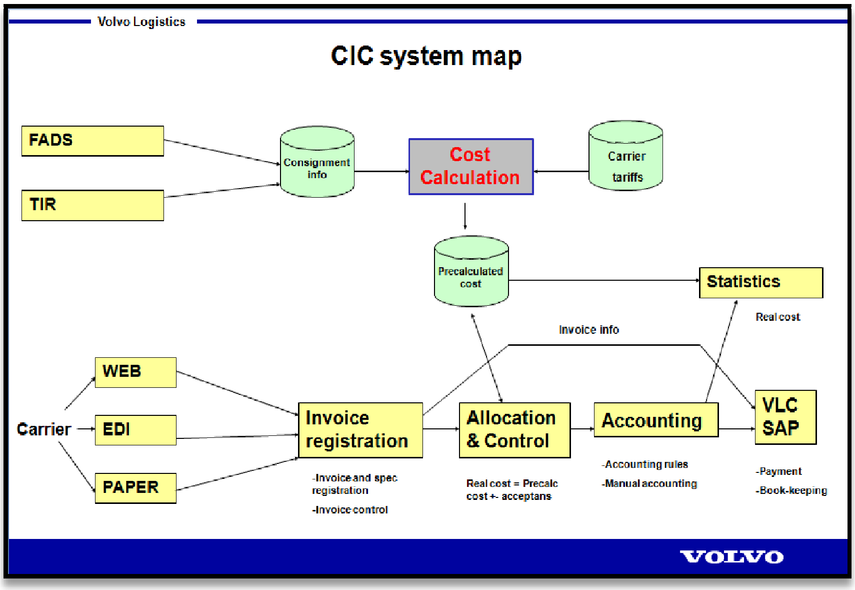

Figure 5-2: CIC, Invoice Auditing System

5.2 Volvo's IT applications; EnvCalc and Proxio

5.2.1 EnvCalc

Emissions from transportation activities are currently calculated using an IT application named EnvCalc. EnvCalc was developed and launched internally at VLC in 2005 in order to simplify the process of comparing two or more alternative logistics solutions from an environmental impact perspective. As shown in Figure 5-3, the application calculates total emissions of $C0_2$, NOx, SOx, and PM for a given transportation set-up and then quantifies the environmental impact of these emissions in terms of Environmental Load Units (ELU)[3].

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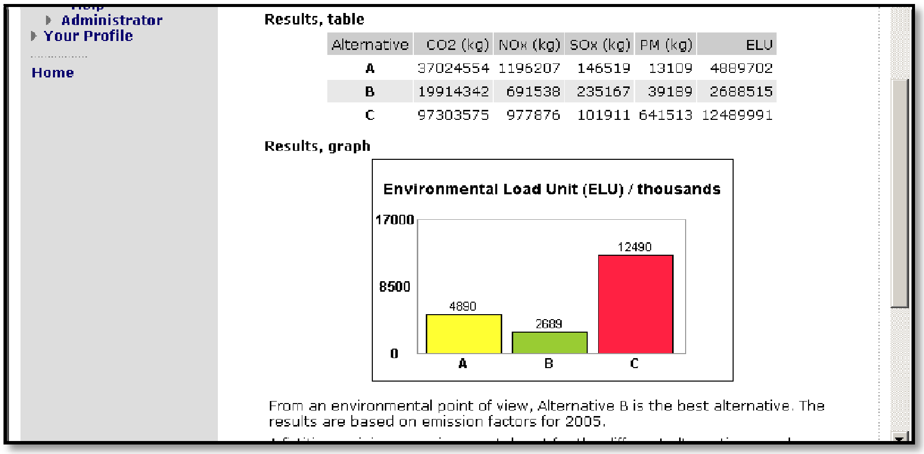
[3] Please refer to section 4.6.1 for more on the ELU unit of measurement.



Results, table

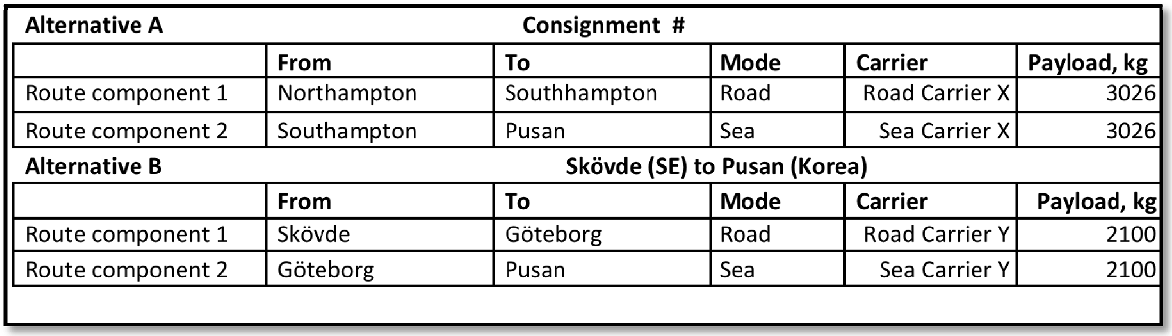
Alternative	CO2 (kg)	NOx (kg)	SOx (kg)	PM (kg)	ELU
A	37024554	1196207	146519	13109	4889702
B	19914342	691538	235167	39189	2688515
C	97303575	977876	101911	641513	12489991

Results, graph

From an environmental point of view, Alternative B is the best alternative. The results are based on emission factors for 2005.

Figure 5-3: EnvCalc Emission Totals, in Kg and ELU

EnvCalc is used primarily by the Core Values department and the Inbound Logistics Development (ILD) department to perform EIAs when a new logistics solution has been developed or changes to an existing set-up have been made.



Alternative A		**Consignment #**			
	From	**To**	**Mode**	**Carrier**	**Payload, kg**
Route component 1	Northampton	Southhampton	Road	Road Carrier X	3026
Route component 2	Southampton	Pusan	Sea	Sea Carrier X	3026
Alternative B			**Skövde (SE) to Pusan (Korea)**		
	From	**To**	**Mode**	**Carrier**	**Payload, kg**
Route component 1	Skövde	Göteborg	Road	Road Carrier Y	2100
Route component 2	Göteborg	Pusan	Sea	Sea Carrier Y	2100

Table 5-1: EnvCalc Shipment Data Input

As illustrated in Table 5-1, users input shipment data such as point of origin, point of destination, transport mode, specific carrier, and payload (in kg or lbs) for one to two network alternatives.

EnvCalc then calculates total emissions for each alternative by combining this data with carrier emission profiles generated from the annual carrier survey. This process is displayed graphically in Figure 5-4.

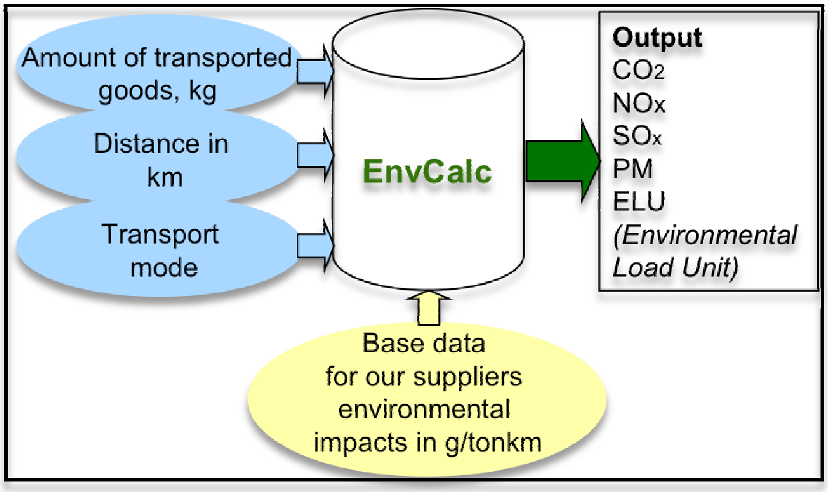


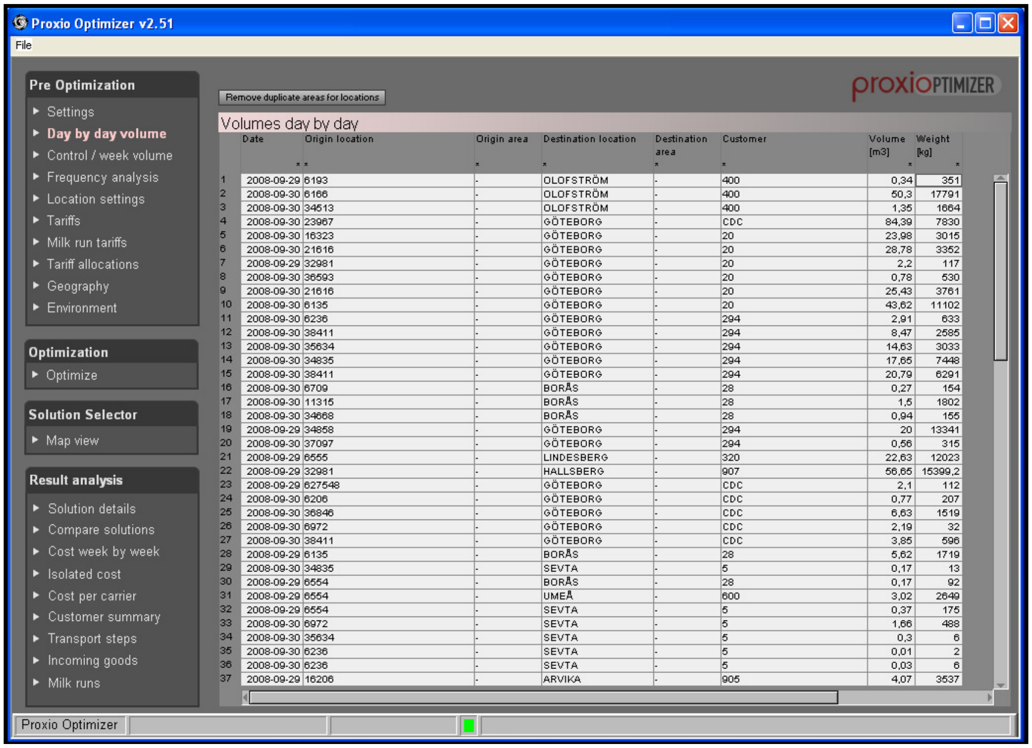
Figure 5-4: EnvCalc Emissions Calculation Model

According to Henrik Erkfeldt, Project Manager for Global Logistics Development at VLC, "*EnvCalc is a linear emissions calculating tool, therefore it does not account for efficiencies from increased fill rates*." EnvCalc bases its calculations on standard emissions of grams per ton-km (gr/tkm) according to the mode of transportation selected. Moreover, EnvCalc is not scalable, agile, or flexible and therefore does not have the capacity to forecast and compare emissions for complex networks and multiple scenarios. For example, if ILD wanted to perform forecast emissions from all logistics network alternatives over a given market area, there could be countless options. Inputting data manually to analyze every possibility would simply not be feasible.

5.2.2 Proxio Optimizer™

Proxio Optimizer™ hereby referred to as 'Proxio,' is an IT application developed in cooperation by AB Proxio and VLC, that allows transport planners to determine optimal transportation networks design and shipment frequency to significantly reduce transportation costs over time (Proxio AB Huvudkontor 2009).

Proxio bases its optimization calculations on historical shipment data extracted from TIR and FADS, and contracted freight rates or 'tariffs' extracted from CIC (see 'data gathering' in section 5.3.3, Inbound Logistics Development Process). The shipment data from TIR and FADS consists of origin-destination locations, shipment dates, as well as physical details on the cargo of the shipment (weight, volume, and/or units) see Figure 5-5. Proxio combines this data with additional variables input by the user such as possible cross-docking locations, available shipment days, and distance between points, and creates an optimized shipment schedule.



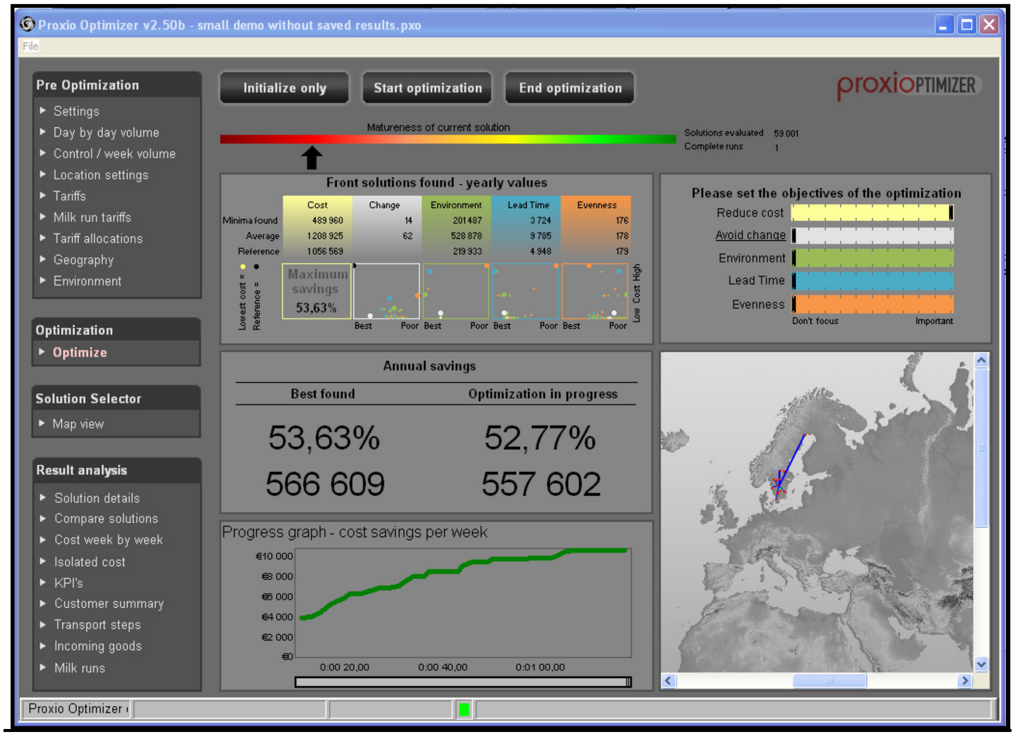
Volumes day by day

	Date	Origin location	Origin area	Destination location	Destination area	Customer	Volume [m3]	Weight [kg]
1	2008-09-29	6193	-	OLOFSTRÖM	-	400	0,34	351
2	2008-09-30	6166	-	OLOFSTRÖM	-	400	50,3	17791
3	2008-09-30	34513	-	OLOFSTRÖM	-	400	1,35	1664
4	2008-09-30	23967	-	GÖTEBORG	-	CDC	84,39	7830
5	2008-09-30	16323	-	GÖTEBORG	-	20	23,98	3015
6	2008-09-30	21616	-	GÖTEBORG	-	20	28,78	3352
7	2008-09-29	32981	-	GÖTEBORG	-	20	2,2	117
8	2008-09-30	36593	-	GÖTEBORG	-	20	0,78	530
9	2008-09-30	21616	-	GÖTEBORG	-	20	25,43	3761
10	2008-09-30	6135	-	GÖTEBORG	-	20	43,62	11102
11	2008-09-30	6236	-	GÖTEBORG	-	294	2,91	633
12	2008-09-30	38411	-	GÖTEBORG	-	294	8,47	2585
13	2008-09-30	35634	-	GÖTEBORG	-	294	14,63	3033
14	2008-09-30	34835	-	GÖTEBORG	-	294	17,65	7448
15	2008-09-30	38411	-	GÖTEBORG	-	294	20,79	6291
16	2008-09-30	6709	-	BORÅS	-	28	0,27	154
17	2008-09-30	11315	-	BORÅS	-	28	1,5	1802
18	2008-09-30	34668	-	BORÅS	-	28	0,94	155
19	2008-09-29	34858	-	GÖTEBORG	-	294	20	13341
20	2008-09-30	37097	-	GÖTEBORG	-	294	0,56	315
21	2008-09-29	6555	-	LINDESBERG	-	320	22,63	12023
22	2008-09-29	32981	-	HALLSBERG	-	907	56,65	15399,2
23	2008-09-29	627548	-	GÖTEBORG	-	CDC	2,1	112
24	2008-09-30	6206	-	GÖTEBORG	-	CDC	0,77	207
25	2008-09-30	36846	-	GÖTEBORG	-	CDC	6,63	1519
26	2008-09-30	6972	-	GÖTEBORG	-	CDC	2,19	32
27	2008-09-30	38411	-	GÖTEBORG	-	CDC	3,85	596
28	2008-09-29	6135	-	BORÅS	-	28	5,62	1719
29	2008-09-30	34835	-	SEVTA	-	5	0,17	13
30	2008-09-29	6554	-	BORÅS	-	28	0,17	92
31	2008-09-29	6554	-	UMEÅ	-	600	3,02	2649
32	2008-09-29	6554	-	SEVTA	-	5	0,37	175
33	2008-09-30	6972	-	SEVTA	-	5	1,66	488
34	2008-09-30	35634	-	SEVTA	-	5	0,3	6
35	2008-09-30	6236	-	SEVTA	-	5	0,01	2
36	2008-09-30	6236	-	SEVTA	-	5	0,03	6
37	2008-09-29	16206	-	ARVIKA	-	905	4,07	3537

Figure 5-5: Screenshot of Historical Shipment Data or 'Day-by-Day Volumes' Input into Proxio

This shipment schedule is a result of a complex analysis performed by Proxio's optimization engine. This analysis takes into consideration a complex logistic system with a multitude of pick-up, cross-dock, and destination locations and a wide array of carrier contracts with variable freight tariffs. It then bases its optimal solution on the weighted importance of different criteria such as cost, lead-time, environment, change avoidance (keeping, to the extent possible, the current docking, warehousing, and transit points), and evenness (maintaining departure/arrival days whenever possible).

When the optimization process is run in Proxio, an average savings amount relative to the current set-up is displayed in the optimization menu. The user can also see the physical flows on a map on the lower right hand side of the screen, as shown in Figure 5-6.



Solutions evaluated 59 001
Complete runs 1

Front solutions found - yearly values

	Cost	Change	Environment	Lead Time	Evenness
Minima found	489 960	14	201 487	3 724	176
Average	1 208 925	62	528 878	9 785	178
Reference	1 056 569		219 933	4 948	179

Annual savings

Best found	Optimization in progress
53,63%	52,77%
566 609	557 602

Figure 5-6: Optimization Menu with Optimization Criteria on the Right Hand Menu

Lastly, Proxio's solutions are displayed in different menus, highlighting the best solution compared to the other available options, and a complete breakdown of the shipment schedule can be obtained.

5.3 Inbound Logistics Development

The VLC Inbound Logistics Development (ILD) department is responsible for the design and implementation of inbound logistics solutions, "*We design and deliver logistics solutions that increase the efficiency within our customer's supply chain process through cost efficient transport set-ups and logistics solutions identified through network simulation, modeling, and total cost calculations*" (Palm 2009). The department's main actions include the optimization or reorganization of current network set-ups and the development of new logistics solutions in new market areas. As shown in Figure 5-7, the Inbound Logistics Development department is comprised of three functions:

Inbound Logistics Development

- Logistics Development
- Transport Development
- Logistics Analysis

Figure 5-7: ILD Functions

5.3.1 Logistics Development

The logistics development function is responsible for managing logistics development projects, either in close cooperation with customers, or pro-actively to develop new solutions and services to meet future customer demands. This process begins with a request for a modification to the current network or the development of a new inbound logistics network in a new market area. This request is made by either a single customer, a group of customers, or internally by VLC management. It is the responsibility of the logistics developers to communicate directly with the customer and/or VLC management to determine the performance requirements of their desired logistics network. Additionally, their responsibility includes managing major project implementations.

The following list provides a short outline of the main reasons for network re-design or development:

- Changes in shipment volumes and pick-up frequency
- VLC KPI's of precision and service quality are not being met
- Cost reduction
- Change of supplier, supplier relocation
- Change of route or transport mode
- Change of carrier
- New inbound traffic set-up (renegotiation of contract for region implying not only change in carrier but also transport routes)

5.3.2 Transport Development

The Transport Development function is responsible for designing the global network of transport solutions. The team's mission is to continuously design and adapt these networks to meet customer and operational demands. It is in the second stage of the ILD process, where transport developers consider the network performance requirements and design alternative solutions to meet the operational demands. The logistics solutions developed in this stage cover all potential network set-ups and transportation solutions that VLC can provide.

5.3.3 Logistics Analysis

The Logistics Analysis function is responsible for providing information to support projects and account managers throughout the logistics development process. VLC employs a team of logistics analysts to determine the feasibility of logistics network set-ups based on statistical analysis and logistics cost calculations. The team is responsible for the development and utilization of the adapted calculation and logistics network simulation tools such as EnvCalc and Proxio. This stage is divided into four sections as illustrated in Figure 5-8:

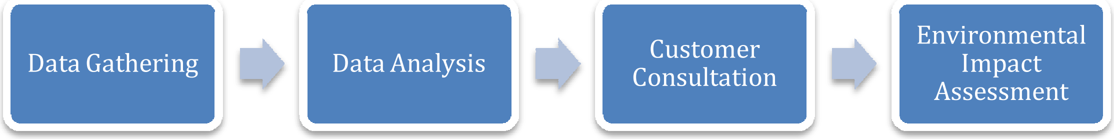


Figure 5-8: Logistics Analysis Stage

Data Gathering

To begin the network optimization process, logistics analysts must first extract historical shipment data from the billing stream in TIR and FADS. Please refer to Table 5-2 for an illustration of the data extracted from the TIR billing stream in an Excel spreadsheet. Every line in the spreadsheet represents one shipment from consignor to consignee and includes the date, weight, volume, and number of terminal handling units (THU's).

The next step is to extract contracted freight rates or 'tariffs' stored in the CIC system. This is currently performed using actual contract documents scanned and stored as PDF files. PDF files are incompatible with Excel; therefore, all tariffs must be manually transcribed in order to be put into Proxio's network optimization interface.

Date	Origin location	Destination location	Customer	Volume [m3]	Weight [kg]	Units [#]
10/01/08	ÅMÅL	BRAÅS	VOLVO CE AB - HAULER & LOADER DIV.	4.66	2956.5	10.5
10/01/08	ÅMÅL	GÖTEBORG	VOLVO CE AB CUSTOMER SUPPORT DIV.	1.83	627.5	5
10/01/08	SÄFFLE	GÖTEBORG	VOLVO CE NORTH AMERICA INC	0.74	236	2

Table 5-2: TIR Billing Statistics

Data Analysis

Once all the necessary data has been collected, it is then uploaded into Proxio via Excel spreadsheets, along with network performance constraints such as; available shipment days, possible cross dock locations, milk-run type configurations, direct line hauls, etc. The logistics analysts then initiate Proxio's network optimization engine.

According to Per Palm, "*Proxio has helped a lot with these types of calculations. It is a lot easier and faster to optimize a network using Proxio, than to do it manually in Excel.*" The end result of Proxio's network optimization engine is a fully developed logistics network shipment schedule optimized for multiple customers, cross docks, and final destinations including shipment dates, volumes and frequencies.

An optimized network allows VLC to increase transport equipment productivity by consolidating their customer's freight onto fewer carriers, thereby, reducing total ton-km and reducing transportation costs.

Customer Consultation

Before the logistics network is implemented, the logistics developers review the solution with each customer and come to a mutual understanding regarding the optimal solution. If a customer rejects the service offering, the Logistics Development department will re-work certain aspects of the network to meet the customer's service requirements. It is important to note however, "*VLC does not re-optimize an entire logistics network for just one customer. It is just not possible to do so*" (Palm 2009).

Environmental Impact Assessment

Environmental impact assessments are conducted once the calculations in Proxio have been performed and the optimal logistics solution has been identified. This process is governed by the Volvo Logistics corporate policy, which states that EIAs must be performed for all changes in Volvo Logistics activities, transport flows and operations that exceed 100,000 Euros (Volvo Logistics 2009).

5.4 Emissions Reporting Process

The emission reporting process is responsible for providing information to customers regarding their past environmental performance. This process is performed by the Core Values department and consists of three sections, as illustrated in Figure 5-9.

Figure 5-9: Emissions Reporting Process

Data Gathering

The reporting process begins with the data gathering stage, involving two separate processes: (i) gathering of shipment data from the inbound databases systems (TIR and FADS), and (ii) gathering of carrier environmental performance data from the annual carrier survey.

The gathering of shipment data begins when the environmental coordinator issues a request for data on all the transport work done for a particular customer over the past two quarters. This request is issued to the ILD department database administrators in Ghent, Belgium and Gothenburg, Sweden. Unlike Inbound Logistics analysts, the environmental Core Values department does not have access to TIR and FADS. As these systems are not linked together to facilitate data sharing, they must contact both Ghent and Gothenburg offices in order to obtain the necessary data. The database administrators then provide the data to the Core Values department in separate files and in separate formats. These files have to be subsequently synchronized, merged, and analyzed manually in order to obtain the amount of emissions per period, per customer.

Data on carrier environmental performance is obtained via the annual carrier survey that is sent out to each carrier within Volvo Logistics' carrier network. This survey asks carriers to provide VLC with their average fill rate (cargo capacity utilization ratio), average fuel consumption and fuel type, number of vehicles in the fleet, engines type (i.e. Euro Class 2-5), curb weight, and the usage (as a percentage of their total transport work) each vehicle type in their fleet for transporting VLC's cargo. Please refer to Appendix 6 for more information on the carrier survey. The environmental Core Values analyst at VLC uses the data gathered in the carrier survey to calculation average emissions in grams/ton-km (gr/tkm) of $C0_2$, NO_x, SO_x, and PM per transport mode.

Data Analysis

The first analysis step is to obtain average emissions per carrier based on the information provided by the carrier survey. The specific data includes fuel consumption per 10 km, the curb weight (capacity of the truck), and engine class. This information is then cross-correlated to a specific emission profile according to engine class and usage percentage. This is done by multiplying engine emission factors (obtained from VLC carrier survey) by the average fuel consumption (liters of diesel per 10km) stated in the carrier survey, and then divided by the capacity of the truck.

In turn, this information is used for obtaining a weighted average of emissions. The result of this calculation is the average emissions per ton-km per carrier and per different truck engine class. A weighted average per carrier is then obtained according to that specific carrier's performance in the period's turnover (the carriers with contracted by VLC the most, have more relevance). This weighted average is then averaged once again by taking all the weighted averages into account and a specific emission profile per region is obtained as a gram per ton kilometer (gr/tkm) value.

Emissions Reporting Process - 'Analysis Stage' Example:

Carrier Survey Data

Company	Units	Model	Engine Type	Usage %	Filling Ratio	Cargo Capacity (tons)	Fuel Usage p/10km (liters)
Carrier Y	3	Scania	2	18 %	95 %	22,8	0,325
Carrier Y	6	Scania	3	26 %	95 %	22,8	0,325
Carrier Y	6	Volvo	4	28 %	95 %	22,8	0,325
Carrier Y	1	Volvo	5	28 %	95 %	22,8	0,290

Diesel Information (Carrier Survey 2008)

Euro	CO2 (kg/liter)	NOx (kg/liter)	SOx (kg/liter)	PM (kg/liter)
0	2,660	0,0559	0,00059	0,00280
1	2,660	0,0319	0,00059	0,00143
2	2,660	0,0286	0,00059	0,00061
3	2,660	0,0214	0,00059	0,00043
4	2,660	0,0150	0,00059	0,00009
5	2,660	0,0086	0,00059	0,00009

From these two sets of data, the following formula is applied:

Emission factor (kg/liter) * fuel usage (l/10km) *1000 (conversion kg to grams)

÷

Cargo Capacity (tons)

Equation 1: Calculation of gr/tkm

The result of the ensuing calculation is the emission profile per engine type:

Emissions per Engine Type (Carrier Y)

Euro	CO2 (grtkm)	NOx (grtkm)	SOx (grtkm)	PM (grtkm)
2	37,917	0,4075	0,00838	0,00873
3	37,917	0,3052	0,00838	0,00610
4	37,917	0,2137	0,00838	0,00122
5	33,833	0,1090	0,00748	0,00109

Once this emission profile is obtained, a weighted average of emissions according to the actual usage of the trucks is calculated. Subsequently, one can see that Euro 2 engines represent 18% of total work done, Euro 3 engines represents 26% and so on. A weighted average according to usage percentage is then obtained by multiplying emissions per engine type * usage % for each Euro engine type. The total sum of these values represents the emission profile for Carrier Y.

Emissions per Engine Type (Carrier Y)

Euro	Usage %	CO2 (grtkm)	NOx (grtkm)	SOx (grtkm)	PM (grtkm)
2	18%	6,652	0,071	0,00147	0,00153
3	26%	9,978	0,080	0,00221	0,00161
4	28%	10,643	0,060	0,00235	0,00034
5	28%	9,497	0,031	0,00210	0,00031
Total	**100%**	**36,770**	**0,242**	**0,008**	**0,004**

This process is repeated for all carriers in the carrier survey. The results are then weighed according to each carrier's percentage of the total turnover, and a general emission profile is obtained for all VLC road transport carriers.

		Emissions per Carrier				Weighted Emissions per Turnover			
Company	**Turnover %**	**CO2 (grtkm)**	**NOx (grtkm)**	**SOx (grtkm)**	**PM (grtkm)**	**CO2 (grtkm)**	**NOx (grtkm)**	**SOx (grtkm)**	**PM (grtkm)**
Carrier W	21%	36,770	0,242	0,00813	0,00379	7,722	0,051	0,002	0,001
Carrier X	24%	29,802	0,192	0,00659	0,00350	6,258	0,040	0,001	0,001
Carrier Y	33%	49,701	0,283	0,01099	0,00466	10,437	0,059	0,002	0,001
Carrier Z	22%	38,000	0,290	0,00840	0,00568	7,980	0,061	0,002	0,001
		VLC Road Emission Profile				**32,397**	**0,212**	**0,00716**	**0,00370**

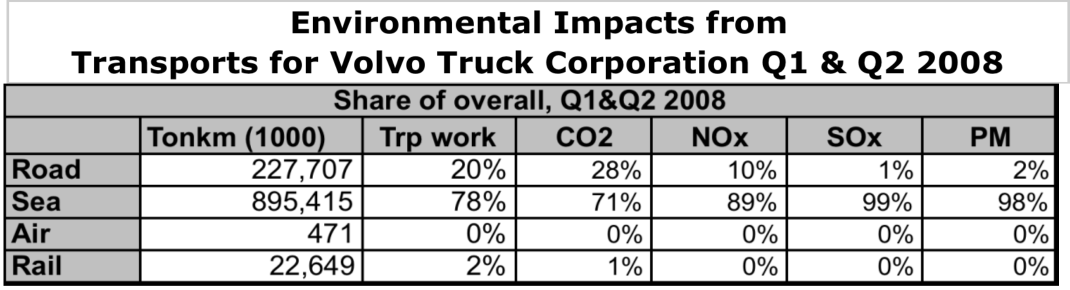
The final step is to take the VLC Road Emission Profile and multiply it by the total ton-km per customer and per mode of transportation obtained from the TIR and FADS database systems. The end result is total emissions for the period per customer.

Reporting / Communicate Results

The emission reports are intended to show the environmental impact from a customer's transport activities and provide basic facts to help the customer put the results in proper context. Emissions can be shown per flow (inbound, outbound), factory, transport mode, produced unit, etc.

This allows the customer to obtain a clear understanding of the environmental impact from their transport activities. These reports provide customers with data on emission levels, which can be useful in discussions with authorities, supporting green marketing initiatives, and measuring progress towards emission reduction targets.

Figure 5-10, is a screen capture from an Emissions Report prepared for Volvo Trucks Corporation, showing emissions from total transport work from Q1-Q2, 2008.



Environmental Impacts from Transports for Volvo Truck Corporation Q1 & Q2 2008

	Share of overall, Q1&Q2 2008					
	Tonkm (1000)	**Trp work**	**CO2**	**NOx**	**SOx**	**PM**
Road	227,707	20%	28%	10%	1%	2%
Sea	895,415	78%	71%	89%	99%	98%
Air	471	0%	0%	0%	0%	0%
Rail	22,649	2%	1%	0%	0%	0%

Figure 5-10: Environmental Impacts from Transports for Volvo Truck Corporation 2008

"The ultimate authority must always rest with the individual's own reason and critical analysis."

— Dalai Lama

Chapter 6:

Empirical Analysis

This chapter analyzes the empirical data gathered throughout the case study at Volvo Logistics. The findings are presented in relation to people, processes, and technology (see Figure 6-1). The development of these three areas is required for VLC to effectively and efficiently meet the increased demands for environmental impact assessments and incorporate environmental cost information in their logistics network management. This chapter concludes with Ishikawa's cause and effect diagram, which is used to summarize the identified sub-problems and relate them to people, processes, and technology.

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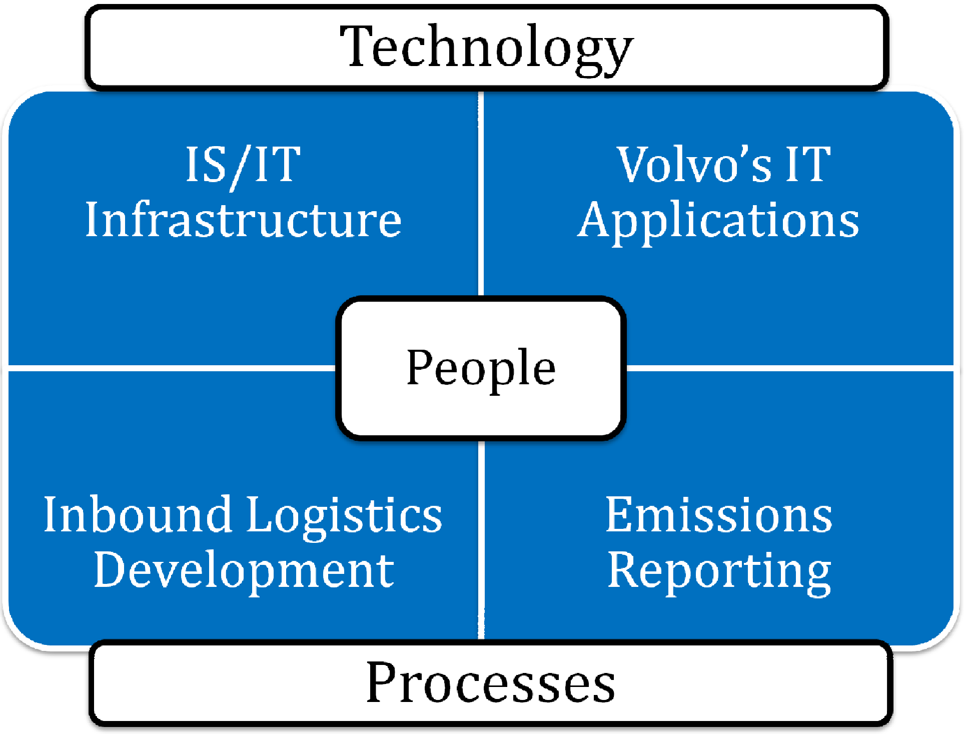

Figure 6-1: Empirical Analysis: People, Process, and Technology

6.1 People

6.1.1 Data Quality

"*Data quality is bar none the single most important thing that will ensure or destroy business process success*."(Boyle, Sokol, & Johnsen 2009) With this in mind, the authors have indentified that poor data quality is a major issue confronting VLC.

"We have huge doubts about our data reliability. Not in the big scope, but in details. When you try to drill down to analyze specific supplier-receiver relationships, there is a lot of dirt on the data." (Erkfeldt 2009) According to Per Palm, the data in TIR and FADS is unreliable because, "*It is often put into the system incorrectly by individuals working in the inbound logistics operations, either at the terminal, supplier, or destination locations*."

The following is a list of reliability issues identified in shipment data extracted from TIR and FADS:

- Distances from supplier to factory are calculated based on country-code to country-code relationships
- Pick-up and delivery distances are not accounted for
- Intermodal transports are not accounted for
- Transport modes are often estimated and transport services are not identified (normal transports, express shipments, express air etc.)
- Freight specification (weight and volumes) are often wrong
- Driving conditions are not accounted for

Data reliability is also an issue with the data obtained from the annual carrier survey. As previously noted, data on carrier environmental performance is collected via the carrier survey. The problem is that the information each carrier discloses represents the total transport work they have conducted with their fleet of vehicles over the past year for all shippers. Regarding fill rates for example, the fill rate percentage provided in the carrier survey might not be an actual reflection of the fill rates that apply to the routes in which VLC's goods are shipped, and currently there is no way of verifying if these fill rates are accurate or not.

Determining the accurate fill rate is of particular importance in the case of LTL shipments. With FTL shipments, fill rates are not crucial because no matter how full the trailer is, 100% of emissions are allocated to VLC's goods. For LTL transports however, VLC shares the trailer with other shipper's goods. Therefore, emissions have to be allocated according to: (i) the amount of cargo belonging to VLC, (ii) the amount of cargo belonging to other shippers, and (iii) the associated fill rate of the load unit. Collecting all of this data from all of VLC's carriers via the annual carrier survey presents a wider array of problems that would have to be solved. Nevertheless, the point remains that the reliability of fill rates contained in the carrier survey is questionable at best.

6.1.2 Insufficient Human Resources and Training for Performing EIAs

As previously noted, ILD uses EnvCalc to conduct EIAs, but often neglects to perform these assessments due to EnvCalc's limited capability (Carlsson 2009). At the moment, there is no environmental training given to members of the ILD department above and beyond the specialized training needed to use EnvCalc. Whenever EnvCalc is unable to perform the calculations as needed, ILD requests assistance from the Core Values department. All requests for assistance go to the environmental Core Values analyst. This individual is the only person with the required training to perform EIAs when EnvCalc is unable to do so. The Core Values analyst must then compile environmental and transport data from multiple systems and perform manual calculations on Microsoft Excel. This means the results are slow to obtain and the potential for human error increases as the logistic systems become more complex. In addition, the environmental Core Values analyst is the only person with the required skill set to administer the annual carrier survey and produce the bi-annual customer emissions reports.

Another problem detected during the case study is that once the EIA is completed and the bi-annual emissions reports are produced, there is a disconnect between management and operations. According to Fredrik Olausson, Account Manager for Volvo Trucks in Gothenburg, the present environmental strategy is not adequately transmitted to the operational people. People at the operational level are shown the environmental reports but they are not told what they can do to improve performance. Their job description does not include any kind of environmental focus and they are evaluated according to their established KPIs which include (i) arrival precision and (ii) cost savings (Olausson 2009). Wu and Dunn (1995) argue that translating environmental strategy into day-to-day operations is one of the major challenges facing logistics managers today. Continuing this thought, McKinnon (1994) states that the 'greening' of a firm's logistics activities at the operational level will require nothing short of a change in management culture and strategic priorities. A change in corporate culture and management priorities could lead to increased training for operational personnel in conducting EIAs.

6.1.3 Poor Managerial Support and Direction for IT Development Initiatives

Another important issue is the lack of managerial support and direction given to overhauling VLC's IS/IT infrastructure to facilitate organization-wide data sharing and improved data quality. As mentioned in the empirical framework, TIR, FADS, and CIC operate independently of each other, which hinders data accessibility, quality and visibility throughout the organization. There is a proposed central IT development project for VLC's inbound logistics operations called Advanced Total Logistics for Automotive Supply (ATLAS), which could solve the problem caused by the numerous fragmented database systems. ATLAS however, is far behind schedule and VLC's current recession management policies have tightened constraints on available IT development resources, so further delays are to be expected[4]. According to Henrik Erkfeldt (2009), ATLAS is functioning today as a customer shipment booking application but is not functioning in the capacity it was originally intended for. Erkfeldt believes, "*It may be another twelve to twenty four months before we see ATLAS fully implemented*."

Lennart Nyström, an external IT Consultant for Volvo Information Technology, believes there is a lack of support and direction directed towards the implementation of ATLAS. ATLAS is not able to link the current systems together because as it develops and advances closer to full implementation, TIR, FADS, and CIC keep developing as well. In a sense, this is a vicious cycle. ATLAS is delayed because resources are being directed to the marginal development of other systems, and as other systems continue to develop, ATLAS continues to lag behind. Until ATLAS is given priority status and the resources necessary for its full implementation, this problem will continue to persist within VLC's IS/IT infrastructure.

---

[4] VLC has implemented corporate recession management policies to cut costs during the global economic downturn. An in-depth discussion on these policies is outside the scope of this thesis.

6.2 Processes

6.2.1 Inbound Logistics Development Department

Emissions Forecasts and Logistics Costs Calculated Separately

During the inbound logistics network development process, emissions forecasts are conducted independently from logistics costs calculations. As a result, they are not regarded as an important factor in the logistics network design process. Emissions levels are forecasted using EnvCalc after the logistics network has been optimized based on costs calculated by Proxio. Due to the nature of this current process, emissions forecasts are conducted as a reactionary measure, which eliminates the possibility of incorporating environmental cost information into the logistics network management decisions. According to Agneta Carlsson of VLC's Core Values department, "*Volvo Logistics needs an application that will allow us to optimize logistics network set-ups based on transport cost and emissions forecasts for multiple scenarios, and present this information to the decision makers for planning and network design purposes.*" At the moment this is not the case as the decision makers already have a network design chosen before they receive information on emissions. Taking steps to calculate emissions forecasts and logistics costs simultaneously is a progressive initiative in the logistics industry. Jahre et al. (2004) state that this concept is an expansion of the traditional view of logistics in that environmental variables are used as complementary criteria in addition to financial criteria, to determine the effects of a proposed or operational logistics solution.

Manual Data Extraction and Manipulation

As noted in the empirical framework, shipment data from inbound logistics operations is extracted from the TIR and FADS billing stream, freight rates are stored in the CIC system, and data on carrier environmental performance is stored in a separate system managed by the Core Values department. These systems are not linked together which would facilitate data sharing and efficient extraction. Therefore, the ILD analysts must initiate multiple queries in each system to extract the desired data.

Once the data is extracted, it must be manually restructured and complied in order for it to be used for inbound logistics development. For example, transport data extracted separately from TIR and FADS is presented in Excel spreadsheets that must be manually synchronized by adding or deleting columns, or changing column orders. Macros do not work to facilitate this process. Furthermore, freight rates stored in CIC are actually scanned PDF documents and must be transcribed onto Excel spreadsheets by physically typing the data into an Excel template. This process of manually extracting and re-formatting data draws on company resources, creates time delays, and increases costs.

6.2.2 Core Values Department

Emissions Reporting Process Needs Standardization

In order for VLC to meet the increased demand for EIAs in an efficient and effective way, the emissions reporting process outlined in the empirical framework needs to be standardized and improved. We have identified three main problem areas, listed in priority sequence that must be addressed to solve this process-oriented problem.

1. *Data Extraction:*

The data extraction process itself is highly inefficient as it involves a number of people and manual processes. The Core Values analyst does not have access to TIR and FADS and since these systems are not linked together which would facilitate data sharing, they must email or telephone database administrators in both the Ghent and Gothenburg Volvo Logistics offices in order to obtain the necessary data. This requires additional human resources and generates a time delay that can range from one-two days, up to an entire week, depending on the present workload of the database administrators.

2. *Emissions Reporting Methodology*

As explained in the empirical framework, there are several calculations involved when obtaining VLC carrier emission profiles. In addition to the weighted average by transport activity, a weighted average according to turnover must also be obtained. These calculations are currently performed on Excel spreadsheets, and involve multiple formulas and cut and paste operations, which make this process slow and prone to error.

Another problem is the fact that VLC uses a 'one-size fits-all' emission profile for all road operations. This could be convenient given the resources currently available, but may lead to loss of accuracy in the results. One carrier's environmental performance can be significantly different from another. For example, if the user wants to obtain emissions per customer, there may be routes covered by one carrier for just one of VLC's customers whose performance may be significantly different from the general average. In the end, the accuracy and reliability of results does not lend itself to a per carrier evaluation of emissions according to actual transport work done. In the current methodology, all of the carriers' environmental performance is the same.

3. *Reporting Process*

The current reporting process is limited due to the fact that it only gives a general picture of total emissions per customer divided by produced unit. It is not possible for a customer to find out what their main sources of emissions are, in order to analyze total emissions in relation to per carrier or per factory emissions. VLC is now offering this flexibility as an element of their emissions reporting service meaning a flexible reporting template is needed. The implementation of additional reporting capabilities using the current methodology would create a very inefficient manual process. It is interesting to note that this process has remained unchanged for approximately five years. The demands on environmental information have changed dramatically during that time; however, IT resources have not. The environmental Core Values analyst acknowledges the fact that this process is not the best way to produce emissions reports, *"This process has been in place for many years and has not changed since it was originally implemented"* (Carlsson 2009).

6.3 Technology

6.3.1 *Fragmented IS/IT Infrastructure*

As noted in the empirical framework, transport data on inbound logistics operations is extracted from the TIR and FADS billing stream, freight rates are stored in the CIC system, and data on carrier environmental performance is stored in a separate system managed by the Core Values department. The problem is that none of these systems are linked together to facilitate data sharing throughout the organization. The user must initiate multiple queries in each system in order to extract the desired data. This presents complications as the user must learn how to operate different systems, or contact multiple departments in order to extract the necessary data.

Additionally, the existence of multiple systems means there is no standardized data format. Therefore, once data is extracted it must be manually restructured and complied in order for it to be used in inbound logistics development and emissions reporting. For example, transport data extracted separately from TIR and FADS is presented in non-synchronized Excel spreadsheets that must be matched up by adding or deleting columns, and changing column orders. Freight rates stored in CIC are saved in PDF documents and must be manually transcribed onto Excel spreadsheets. This manual data format manipulation draws on company resources, creates time delays, and increases costs.

Furthermore, once data is extracted from the TIR and FADS billing stream, it is at least three months old. Up to date data cannot be obtained since is contains many errors when it is initially put into the system. Data must be cleaned and manually verified by the invoicing department before being used for logistics network design or emissions reporting. Once again, because these systems are not linked together, the vast amount of data handled means this process takes at least three months.

The ideal condition at VLC would consist of an integrated data base system where all inbound logistics and environmental information is stored in a central data warehouse. This set-up was proposed by a previous thesis study conducted at VLC in 2006 which concluded, "*VLC would benefit from a uniform way of working which would be greatly supported with fewer systems… the use of so many different database systems presents neither financial nor usability benefits*"(Linghammar 2006).

6.3.2 Applications are Incapable of Meeting User Requirements

EnvCalc Cannot Handle Complex Calculations

As noted in the empirical framework, EnvCalc's capabilities are extremely limited. Henrik Erkfeldt, Project Manager for Global Logistics Development at VLC, believes the data behind the application is useful, but the increased demand for EIAs regarding both emissions forecasts and historical emissions reports, has rendered the tool almost obsolete (Erkfeldt 2009). EnvCalc simply cannot process the data from all logistics network alternatives over a given market area, nor can it the handle high volume of shipment data included in each bi-annual reporting period. As a result, when the ILD cannot perform EIAs using EnvCalc, they turn to the Core Values analyst for assistance. This individual must then produce EIAs by performing manual calculations on Excel spreadsheets, which is a slow, complex, and manual process.

EnvCalc Cannot Account for Increased Emissions Efficiency from Freight Consolidation

As mentioned in the empirical framework, EnvCalc is a linear calculation tool using static gr/tkm emission figures, multiplied by distance and payload to calculate total emissions. In doing so, EnvCalc does not take into account the efficiencies derived from increasing cargo capacity utilization, otherwise known as 'fill rate.' To illustrate the importance of accounting for these efficiencies please see the example presented in Exhibit 6-1. This example is based on the NTM transportation emissions calculation methodology.

Exhibit 6-1: Increased Efficiency in C0$_2$ Emissions from Freight Consolidation

Company A is sending 3026 kg of finished goods inventory from Northampton (UK) to Southampton (UK). The shipment is being sent with an LTL carrier operating a Euro Class 3 engine and a 25ton trailer.

The carrier's fill rate can range from 50% - 75% - 90% depending on the size and volume of shipments picked up from other shippers. The logistics manager at Company A is curious as to how the level of C02 emissions allocated to his freight may change in light of these varying fill rates.

Payload	3026 (kg)	Type of Carrier	LTL
Distance (km)	180	Fuel Consumption Empty (l/km)	0.236
Fill Rate A	50%	Fuel Consumption Full (l/km)	0.354
Fill Rate B	75%	Type of Engine	Euro 3
Fill Rate C	90%	Truck Capacity (tons)	25

Following the NTM methodology, as presented in the contextual framework, the following table shows the produced C0$_2$ emissions associated with each fill rate. The results show that C0$_2$ emissions decrease by approximately 35% when the fill rate of the truck increases from 50% to 90%.

C0$_2$ Emission Efficiencies			
	Alt. A (50%)	Alt. B (75%)	Alt. C (90%)
Fuel Consumption (1km)	0.295	0.3245	0.3422
Total Emissions (180km) (kg)	140.29	154.32	162.74
Allocated Emissions (kg)	33.96	24.91	21.89

EnvCalc Reports Results in Relation to ELUs

As previously noted, once EnvCalc has processed the data and total emissions per route have been obtained, emissions are then reported in total kilograms per emission and graphed according to their equivalent Environmental Load Unit (ELU).

The main problem with expressing results in ELUs is that this measurement is not an internationally recognized unit of measurement for environmental performance. For example, neither the Swedish Environmental Agency nor the European Environmental Agency have adopted the ELU performance standard. A more effective method of expressing results would be to use a metric that can be applied internationally. This thesis therefore suggests the use of a monetary emissions valuation technique based on the IMPACT study. Please refer to Chapter 4, section 4.6.2 for more information on IMPACT.

Furthermore, according to Fredrik Olausson, VLC Account Manager for Volvo Trucks in Gothenburg, ELUs cannot be easily interpreted by people who see them in the environmental reports. “*They are hard to understand and the real impact cannot be adequately assessed*” (Olausson 2009).

Proxio’s Current Environmental Module is Inadequate

Proxio is a powerful application capable of optimizing VLC’s complex inbound logistics networks to reduce transport costs. In December 2008, AB Proxio released a new version of the application, which included an environmental module capable of measuring $C0_2$ emissions. However, this new module is limited in its functionality as it does not account for efficiencies in volume or emissions of NOx, SOx, or PM. In cooperation with this thesis, Proxio’s developers are working to expand the current environmental module to account for these factors. “*The idea of using Proxio to forecast produced emissions of* CO_2*, SOx, NOx, and PM and integrate this environmental cost information into transport network design and decision making process is something totally new, but we are excited by the potential for Proxio to do this*” (Carlsson 2009).

6.3.3 Ishikawa's Cause and Effect Diagram

This diagram presents a summary of the problems analyzed in Chapter 6 in relation to the *Lean Systems Concept*:

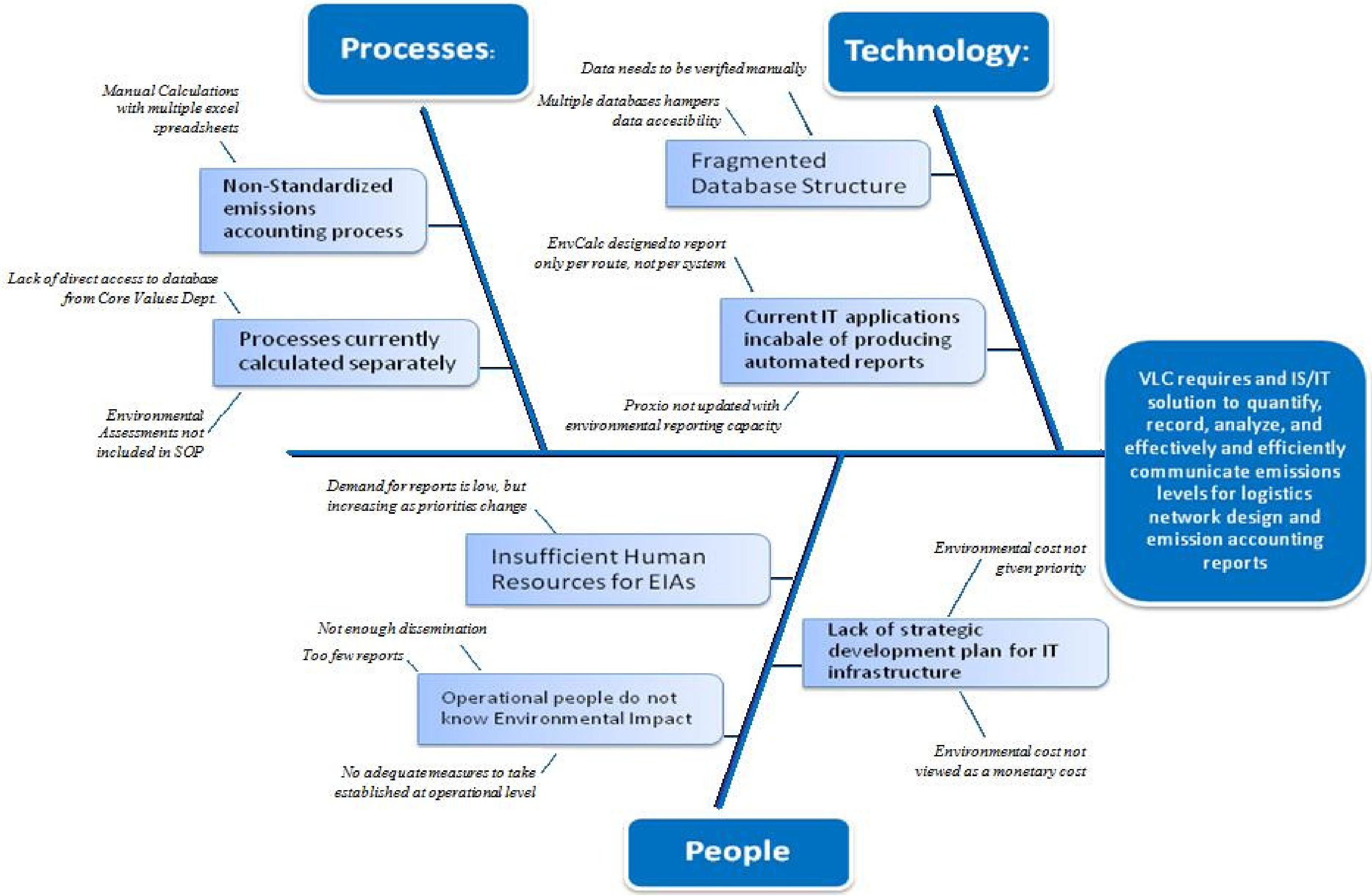

Figure 6-2: Ishikawa's Cause and Effect Diagram

Part 3

Solution Proposal & Conclusion

Part 3 is comprised of the solution proposal for Volvo Logistics and the thesis conclusion. The proposed solution is based on the concept of lean systems development applied to people, processes, and technology. The people and processes components of the solution are presented together in Chapter 7 while technology is presented in Chapter 8. Chapter 9 presents the thesis conclusion, including a discussion on the application of the lean systems concept at Volvo Logistics and recommendations for future research and development in the field of logistics management.

"We can't solve problems by using the same kind of thinking we used when we created them."

— Albert Einstein

Chapter 7:

People & Processes

This chapter presents the solution for Volvo Logistics related to the development of People and Processes. It follows up on the problem areas presented in the empirical analysis and proposes changes to Volvo Logistics' current human resources and inbound logistics operations.

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7.1 People

In today's fast paced global economy, a firm's success relies heavily on innovation, and its ability to adapt to new market demands and competitive pressures. As a consequence an organization's competitive advantage is now largely dependent on the ability of its human capital, or people to learn new skills, take on new responsibilities and rise to meet new challenges. This is exemplified in the following quote.

> *"A work force capable of taking responsibility for its own continuous learning will prove a more precious national asset than countless new factories and equipment."*
>
> – Robert Reich, Former US Secretary of Labour

According to Swank (2003) and Liker (2004), the development of lean systems requires the training and education of human resources to work with new processes and operate new technologies. With this in mind, the authors have identified the need for more environmental training and education for Volvo Logistics personnel in order to improve the emissions forecasting and reporting processes.

7.1.1 Basic Education on Volvo Logistics' Ecological Footprint

Management and employees need to be made aware of how VLC's operations impact the environment and what the implications of these impacts are. This is especially important for managers confronted with logistics network management decisions. They must receive environmental training in order to effectively assess the implications of both the cost and emission levels from proposed network set-ups. It is also important to educate and inform employees so that they understand the importance of corporate initiatives like the $C0_2$ challenge and learn how to incorporate environmental targets in their day-to-day operations.

The authors understand that resources are limited, and organizing a organization-wide environmental education program is not a light undertaking. As a result, it is proposed that the Core Values department put together a basic environmental education package for the three global business operations (GBOs), inbound, outbound, and emballage.

The package should be in line with Volvo's environmental policy as illustrated in Appendix 1, and should contain clear and objective facts on environmental issues, benchmarking statistics, targets, and a description of how each business function within the GBOs impact the environment; and how they can improve their environmental performance. The packages should be sent to each GBO department, followed by a subsequent meeting between the environmental manager and each department head. This follow up meeting is crucial in order to facilitate the formation of an environmental action plan and to ensure that the information reaches all fellow managers and employees throughout the department.

7.1.2 Training in Emissions Calculations and New IT Applications

As noted in the empirical analysis, when the ILD department cannot perform EIAs using EnvCalc, they turn to the Core Values analyst for assistance. The Core Values analyst is the only person at VLC with the training required to make up for EnvCalc's limitations. This should not be the case, as calculating emissions is not a difficult process. VLC employees simply need to know what data to use, what calculation methodology to employ, and how to use the calculation tool, whether it is a module in Excel, EnvCalc, or Proxio. If emissions calculation training were offered to more employees throughout VLC, the efficiency of the EIA process would improve dramatically. Susanna Hambeson, the VLC Environmental Manager, believes that it would be extremely beneficial to have an employee in every department trained in emissions calculations.

> *"These individuals would not need to work in the environmental field fulltime, but if one or two members of every department received training in performing emissions calculations, above and beyond what EnvCalc can provide, then the EIA process would be much more efficient."*
>
> – Susanna Hambeson, 2009

Therefore, the authors propose that the Environmental Core Values department develop a brief emissions calculation course and an accompanying handbook based on the needs for emission calculations at VLC. Each department head within the three GBOs should then select two employees to attend the emissions calculation-training course held by the Core Values department. The course should be conducted periodically, to the degree that it is required and that resources allow. Additionally a forum on the VLC *TeamPlace* intranet portal should be established in which course attendees and other members of the organization are able to share information and offer advice on solving challenging emissions calculation problems.

7.1.3 The Importance of Data Quality

Shipment data is entered into TIR and FADS by individuals working on the operational level at VLC's terminals. As noted in the empirical analysis, when the data is input it is often full of errors, and is therefore not reliable.

Therefore, VLC's environmental training must also cover the importance of data quality. The individuals physically inputting the data need to know that the accuracy of the shipment data they input into TIR and FADS (referring to weight (kg), volumes (m3), transport mode etc.) is a critical component in calculating emissions and reducing costs. If a conscious effort were made to ensure that all shipment data was entered error free, then the validity of the emissions forecasts and reports would be greatly enhanced and the expenses incurred from cleaning and verifying unreliable data could be considerably reduced.

7.1.4 Feedback on Training Programs and Environmental Performance

Once managers and employees are educated in the aforementioned areas, it is essential that they receive feedback on how their actions are influencing VLC's environmental performance.

Feedback should provide information on:

- How are emissions forecasts and EIAs being used?
- What value are they providing the company?
- What has changed as a result?
- How is VLC's environmental performance changing?

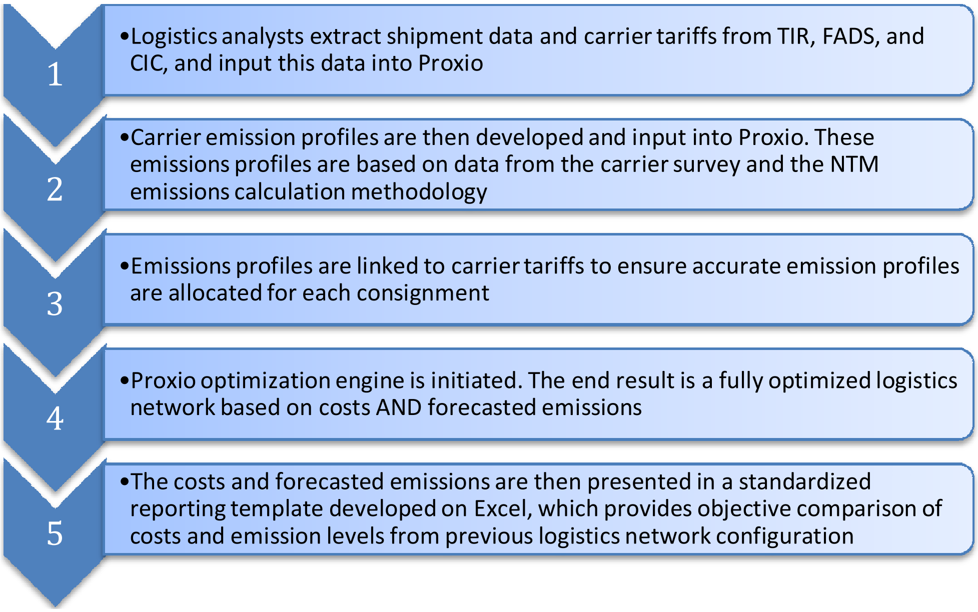
7.2 Processes

As noted in the conceptual framework in Chapter 3, lean systems thinking is about creating more value with less work (Womack and Jones 1994). This is achieved through the design of lean processes which eliminate waste, focus resources on value adding activities, and undergo continuous improvement (Liker 2004, Deming 1989). The authors propose the application of this concept to the process oriented problems identified in the empirical analysis in Chapter 6.

7.2.1 Synchronize Emissions Forecasts and Logistics Cost Calculations

A major problem identified in the empirical analysis, is the separation of emissions forecasts and logistics cost calculations in the inbound logistics development process. The nature of the current process means emissions forecasts are conducted only as a reactionary measure; after the logistics network has been designed based on costs. This eliminates the possibility of incorporating environmental cost information into the logistics network management decisions.

Therefore, the researchers propose a redesign of the inbound logistics development process to synchronize emissions forecasting and logistics costs calculations. The redesigned process is illustrated in Figure 7-1:



1 • Logistics analysts extract shipment data and carrier tariffs from TIR, FADS, and CIC, and input this data into Proxio

2 • Carrier emission profiles are then developed and input into Proxio. These emissions profiles are based on data from the carrier survey and the NTM emissions calculation methodology

3 • Emissions profiles are linked to carrier tariffs to ensure accurate emission profiles are allocated for each consignment

4 • Proxio optimization engine is initiated. The end result is a fully optimized logistics network based on costs AND forecasted emissions

5 • The costs and forecasted emissions are then presented in a standardized reporting template developed on Excel, which provides objective comparison of costs and emission levels from previous logistics network configuration

Figure 7-1: Redesigned Inbound Logistics Development Process

This new process will require the adoption of a lean systems focus including the approval and support of top management, the introduction of new training programs for VLC personnel, the development of new IT applications capable of performing the emissions and cost calculations simultaneously, and a commitment to continuous improvement through the Deming Cycle (Plan, Do, Study, Act) (Deming 1989).

The new IT applications required in support of this redesigned process have been developed by the authors throughout the course of this thesis and consist of: (i) a newly designed environmental module in Proxio and (ii) a standardized emissions and cost reporting template on Excel. Please refer to section 7.1 for more on the required training programs, and Chapter 8 for more on these IT applications.

7.2.2 Standardized Data Extraction Process for ILD and Emissions Reporting

Data extraction is another major process oriented problem highlighted in the empirical analysis. For ILD, analysts must initiate multiple queries in the TIR and FADS systems in order to extract the desired shipment data. Secondly, tariffs stored in CIC are actually scanned PDF documents and must be transcribed onto Excel spreadsheets by physically typing the data into an Excel template. These manual processes draw on company resources, create time delays, and increase costs.

For emissions reporting, the data extraction process is even more inefficient. The Core Values analyst does not have access to TIR and FADS and since these systems are not linked to facilitate data sharing, they must email or telephone database administrators in both the Ghent and Gothenburg Volvo Logistics offices in order to obtain the necessary data. This requires additional human resources and generates a time delay that can range from one to two days, up to an entire week, depending on the present workload of the database administrators.

As a solution, the authors propose that VLC direct more priority and resources towards implementing a central data warehouse for inbound logistics operations. This data warehouse will enable the creation of a standardized data format, improve accessibility to shipment and environmental performance data, and streamline the data extraction process. This will result in a lean data extraction process whereby waste is eliminated through the removal of non-value adding processes. Please refer to the section 8.1.1 for more on the technical aspects of this central data warehouse proposal.

Another solution proposed to VLC is the creation of an online IT application designed to extract data from the database systems and present it on customized Excel spreadsheets. An application of this nature is already in place for similar data extraction requirements at VLC. If set-up for extracting data from TIR, FADS, and CIC, it would both reduce time delays from organizing and preparing data, and increase Proxio's user friendliness. Once again please see the following section for more on the technical aspects of this element of the proposed solution.

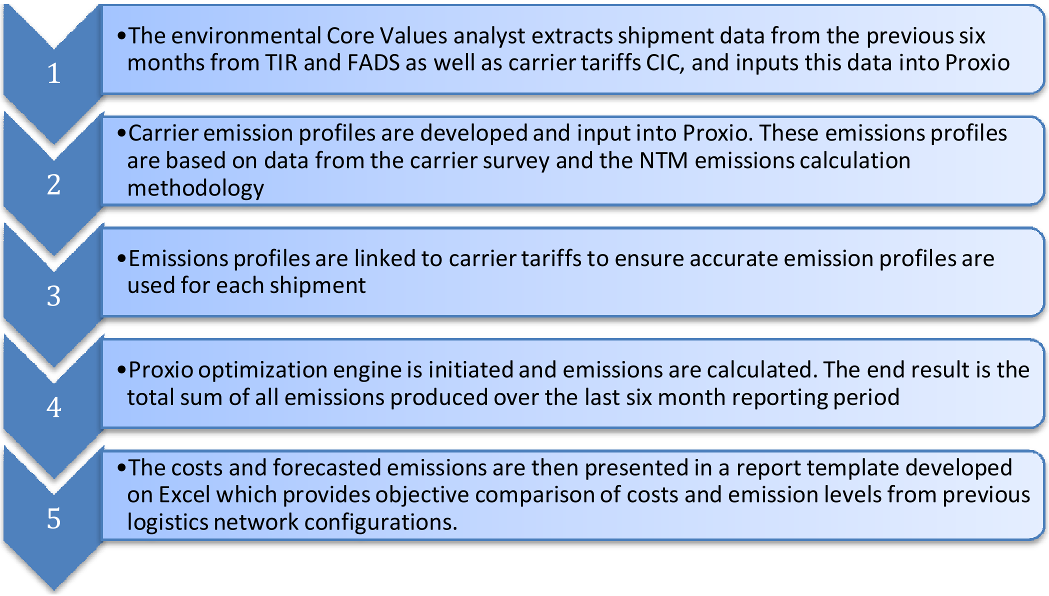
As an immediate solution for the data extraction complications presently affecting VLC, the Core Values analyst needs to be trained and granted access to VLC's Inbound Logistics database systems. This would result in a lean data extraction process whereby the analyst could extract historical shipment data without the need for assistance from database administrators.

This change would enable the Core Values analyst to extract data for each emissions report in a uniform, standardized way, thereby eliminating non-value adding activities and reducing costs. These changes will require the support of top management, employee training programs, and the development of new technologies in regards to the implementation of a central data warehouse and the IT development of an online data extraction tool. Please refer to section 7.1 for more on the required training programs, and Chapter 8 for more on these IT applications.

7.2.3 Redesign Emissions Reporting Process

The current emissions reporting process is entirely manual and gives only a general illustration of total emissions per customer. There are numerous calculations involved in obtaining results, which are currently performed on Excel spreadsheets. These calculations involve multiple formulas and cut and paste operations, which make the process slow and prone to error. Finally, there is no standardized reporting template available to facilitate objective comparison of results to previous emissions reporting periods.

Therefore, the researchers propose a complete emissions reporting process redesign which is closely aligned with the new ILD process presented in section 5.3. In the new process, total emissions for a given VLC customer are calculated using the environmental module in Proxio. Results are then presented on a flexible Excel reporting template, which provides objective comparison to previous emissions reporting periods, and multiple performance metrics (i.e. total emissions, emissions per unit produced, and per factory, as well as the ten largest emission producing supplier-destination relationships). This redesigned process is illustrated in Figure 7-2:



1. The environmental Core Values analyst extracts shipment data from the previous six months from TIR and FADS as well as carrier tariffs CIC, and inputs this data into Proxio
2. Carrier emission profiles are developed and input into Proxio. These emissions profiles are based on data from the carrier survey and the NTM emissions calculation methodology
3. Emissions profiles are linked to carrier tariffs to ensure accurate emission profiles are used for each shipment
4. Proxio optimization engine is initiated and emissions are calculated. The end result is the total sum of all emissions produced over the last six month reporting period
5. The costs and forecasted emissions are then presented in a report template developed on Excel which provides objective comparison of costs and emission levels from previous logistics network configurations.

Figure 7-2: Redesigned Emissions Reporting Process

This new process will require the adoption of a lean systems focus including the approval and support of top management, as well as the introduction of new training programs (people), and the development of new IT applications capable of performing the emissions and cost calculations simultaneously (technology).

These new IT applications were developed by the authors throughout the course of this thesis and consist of: (i) upgrading the environmental module in Proxio and (ii) standardizing the emissions reporting template on Excel. These applications will be described in detail in the following Chapter.

“The number one benefit of information technology is that it empowers people to do what they want to do.”

— Steve Ballmer

Chapter 8:

Technology

This chapter is divided into three sections: (i) data input, (ii) data analysis and (iii) information output. Each of these sections contains technological improvements that are to be used by VLC personnel to facilitate the process improvements described in the previous section. In accordance with the thesis objective, the goal of these technological improvements is to facilitate the production of EIAs, therefore promoting the integration of environmental cost information in logistics network management.

Chapter Outline

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8.1 Data Input

8.1.1 Data Quality

1. Implement a Central Data Warehouse for Shipment and Environmental Data

The poor quality and inaccessibility of data stored in VLC's inbound logistics database systems has been a constant topic of discussion throughout this case study.

As a solution, the authors propose that VLC prioritize and direct more resources towards implementing a central data warehouse to standardize the format and improve accessibility to inbound shipment and environmental performance such as emission profiles and carrier fill rates data. The central data warehouse as proposed in this thesis is illustrated in Figure 8-1:

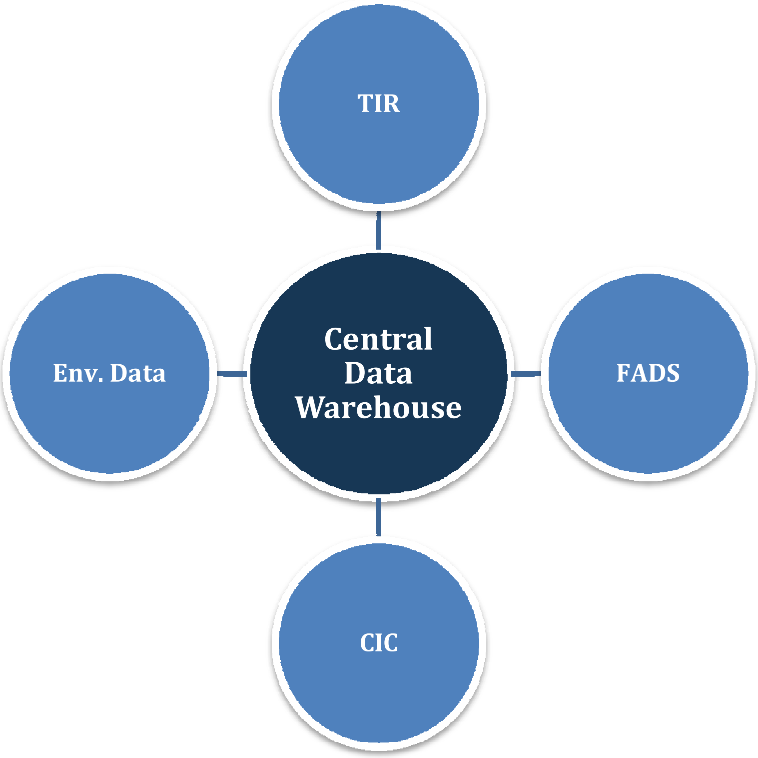


Figure 8-1: VLC Central Data Warehouse Model

The implementation of such a system would improve the data extraction process by removing the non-value adding activities such as; manually extracting data from multiple locations, cleaning and verifying unreliable data, and the manual synchronization of Excel spreadsheets.

A data warehouse of this nature could also serve to enable a direct flow of data into Proxio, thereby eliminating the current manual process of data extraction and input. The authors have proposed this development to both VLC management and AB Proxio. Both parties agreed that it would be feasible and very beneficial if a central database were in place.

2. Case Specific Data Gathering

According to NTM, the ideal scenario for calculating emissions is to use case specific data whenever possible. Data showing carrier fill rate fluctuations along the transport network does not exist therefore, using an average fill rate for calculating emissions is currently the best option for VLC.

New onboard computer systems are under development which will allow shippers and transportation service providers to measure the different variations in fill rates over the course of the transport network, as well as total driving distance, driving conditions, and fuel consumption. An example of this type of technology is the Dynafleet system being developed and tested by Volvo Technology as part of the EU-sponsored Euro FOT initiative, as illustrated in Exhibit 8-1: Euro FOT Initiative.

The first wave of this technology is available however, it has not yet seen strong market penetration. As a result, VLC has not mandated it as a carrier requirement. The authors strongly advise VLC to implement this technology as a carrier requirement in the coming years as it will enable VLC to obtain a reliable fill rate for the load units its goods are carried in, in contrast to the high level averages they currently receive through the carrier survey. In turn, this would result in a more accurate allocation of emissions to VLC's goods based on VLC's actual load factor and a more accurate representation of VLC's transport costs.

Exhibit 8-1: Euro FOT Initiative

Euro FOT is an EU initiative to reduce the transport sector's environmental impact. It is based on the view that fossil fuel powered transportation services threaten human health, negatively affect environmental quality and make a significant and growing contribution to climate change, while traffic congestion reduces economic productivity and raises costs for every European citizen. This initiative strives to expand the use of IT systems in carrier fleets to make driving safer and more efficient (Euro FOT 2009).

8.1.2 Streamline and Standardize Data Extraction Process

1. Data from Customers

The process for obtaining data from customers regarding expected delivery dates, shipment volumes, and shipment origins and destinations should remain unchanged. The current *TeamPlace* platform is an adequate way of sharing information from the customer throughout all relevant departments. Access to this platform is simple and widespread.

2. *Data from Database Systems*

As mentioned in the empirical analysis, extracting data from the VLC database systems is a complicated process. When a query is made for day-by-day shipment data, analysts obtain an Excel spreadsheet with raw data. Subsequently, they have to organize this data into a format that can be put into Proxio and this can be an exhaustive process given Proxio's rigid format requirements. Although the ILD department is somewhat accustomed to this process, other departments, such as Core Values are not. This extraction process presents a significant barrier to the effective utilization of Proxio for emissions reporting.

The implementation of the proposed central data warehouse as previously discussed would be ideal in facilitating data extraction for inbound logistics development and the production of EIAs. However, the process of implementing such a data warehouse is not a light undertaking. Therefore, the authors propose the creation of an online IT application, accessed through the Volvo Intranet designed to extract data from the database systems and present it on customized Excel spreadsheets. An application of this nature is already in place for similar data extraction requirements at VLC. If implemented set-up for extracting data from TIR, FADS, and CIC, it would both reduce time delays from organizing and preparing data, and increase Proxio's user friendliness.

This online tool would consist of two SQL queries: (i) to extract the desired shipment data from the TIR and FADS database systems and (ii) to extract tariff data from the CIC system. The objective of this database query tool is to obtain an Excel spreadsheet in which only the fields required by Proxio would be listed and automatically presented in the correct order. The authors have issued a request to the VLC IT department for the implementation of this tool. According to Lennart Nyström, an external consultant working with Volvo IT, top management must first approve the proposed SQL query process and employees must be properly trained on how to use the tool before it can be fully implemented. When asked about the implementation costs of this tool, Henrik Erkfeldt, VLC IT Project Manager, suggested, "*The value derived from this type of data extraction process would pay off the implementation costs in a very short period of time and should not pose an obstacle to implementation*" (Erkfeldt 2009).

3. *Data Format*

It is crucial that the data extraction tool as described above, presents data on Excel spreadsheets in a uniform, Proxio-compatible format so that the user can simply copy and paste it into Proxio. According to Lennart Nyström, it is simple to program the SQL query tool to extract data according to Proxio's current configuration. It is worth noting that with future system updates, Proxio's data format requirements may change, therefore, it is important to be aware of any necessary changes and update the SQL query tool to extract data in the new format. Another option is to equip the new versions of Proxio with a data translator application, to automatically reformat Excel spreadsheets from the SQL query tool.

This would enable the efficient use of the new version without having to change the data format from the SQL query tool. A meeting was held with AB Proxio to discuss the data format requirements of future Proxio versions and the possibility of equipping newer versions with a data translator. It was agreed by all parties to try to keep the present format consistent and once demand is high enough, a data translator could accompany newer versions.

8.2 Data Analysis

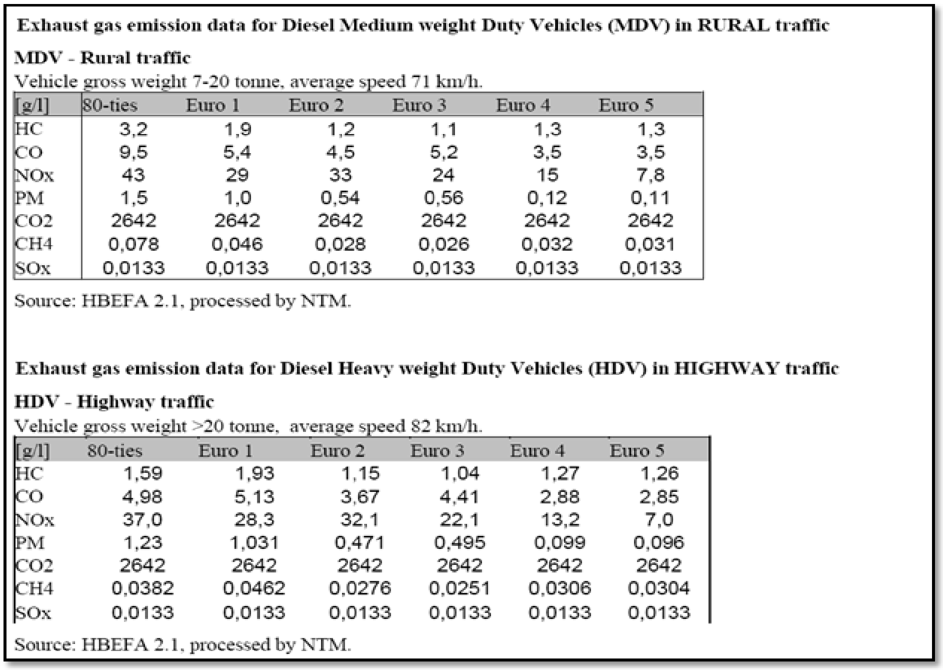
This section presents the technical process behind the development and implementation of Proxio's environmental module. The authors have developed this module throughout this thesis as part of the proposed solution for VLC. The module has been designed to meet NTM's highest standard for road transport emissions calculations accuracy level three. Please refer to Appendix 7 for a description of NTM accuracy level three.

8.2.1 Generate Emission Profiles

The first stage in developing and implementing Proxio's environmental module is to generate individual carrier emission profiles in grams per ton-km (gr/tkm). Once developed, these emission profiles are to be linked to tariffs governing the day-by-day shipments transported by each carrier. This section presents the five-step calculation process developed to generate carrier emission profiles.

Step 1

Establish emission values for each carrier in the annual carrier survey according to the type of engine and type of vehicle (Euro Class and MDV/HDV/Mega). These emission values are taken from NTM (2007) and are illustrated in Exhibit 8-2:



Exhaust gas emission data for Diesel Medium weight Duty Vehicles (MDV) in RURAL traffic

MDV - Rural traffic

Vehicle gross weight 7-20 tonne, average speed 71 km/h.

[g/l]	80-ties	Euro 1	Euro 2	Euro 3	Euro 4	Euro 5
HC	3,2	1,9	1,2	1,1	1,3	1,3
CO	9,5	5,4	4,5	5,2	3,5	3,5
NOx	43	29	33	24	15	7,8
PM	1,5	1,0	0,54	0,56	0,12	0,11
CO2	2642	2642	2642	2642	2642	2642
CH4	0,078	0,046	0,028	0,026	0,032	0,031
SOx	0,0133	0,0133	0,0133	0,0133	0,0133	0,0133

Source: HBEFA 2.1, processed by NTM.

Exhaust gas emission data for Diesel Heavy weight Duty Vehicles (HDV) in HIGHWAY traffic

HDV - Highway traffic

Vehicle gross weight >20 tonne, average speed 82 km/h.

[g/l]	80-ties	Euro 1	Euro 2	Euro 3	Euro 4	Euro 5
HC	1,59	1,93	1,15	1,04	1,27	1,26
CO	4,98	5,13	3,67	4,41	2,88	2,85
NOx	37,0	28,3	32,1	22,1	13,2	7,0
PM	1,23	1,031	0,471	0,495	0,099	0,096
CO2	2642	2642	2642	2642	2642	2642
CH4	0,0382	0,0462	0,0276	0,0251	0,0306	0,0304
SOx	0,0133	0,0133	0,0133	0,0133	0,0133	0,0133

Source: HBEFA 2.1, processed by NTM.

Exhibit 8-2: NTM (2007) MDV and HDV Trailer Emission Values

It is important to note that the current version of NTM (Version 2007-04-13) does not provide information regarding emission data for Mega trailers in highway traffic. For the purpose of this case study, the authors will assume Mega trailer emissions are equal to an HDV trailer. NTM, however, is currently working on an updated version which will have more up-to-date and comprehensive data including Mega trailer emissions.

Step 2

Obtain a weighted emission average per carrier using information provided by the carrier survey and NTM (Table 8-1) and calculate a weighted average according to the percentage of transport work performed by each type of truck (Table 8-2). This process is illustrated below:

Carrier Survey Information on Carrier X				Data Matched According to NTM (kg/l) (2007)				
Company	**Units**	**Engine**	**% of Transport Work Done**	**CO2**	**NOx**	**SOx**	**PM**	**Truck Type**
Carrier X	4	3	20%	2,642	0,0221	1,33E-05	0,000495	HDV
Carrier X	2	3	20%	2,642	0,0221	1,33E-05	0,000495	HDV
Carrier X	2	4	10%	2,642	0,0132	1,33E-05	0,000099	HDV
Carrier X	15	4	0%	2,642	0,0132	1,33E-05	0,000099	HDV
Carrier X	20	3	1%	2,642	0,0221	1,33E-05	0,000495	HDV
Carrier X	27	3	5%	2,642	0,0221	1,33E-05	0,000495	HDV
Carrier X	9	3	1%	2,642	0,0221	1,33E-05	0,000495	HDV
Carrier X	9	3	1%	2,642	0,0221	1,33E-05	0,000495	HDV
Carrier X	15	3	6%	2,642	0,0221	1,33E-05	0,000495	HDV
Carrier X	6	3	4%	2,642	0,0221	1,33E-05	0,000495	HDV
Carrier X	3	3	4%	2,642	0,0221	1,33E-05	0,000495	HDV
Carrier X	2	3	4%	2,642	0,0221	1,33E-05	0,000495	HDV
Carrier X	2	3	4%	2,642	0,0221	1,33E-05	0,000495	HDV
Carrier X	1	4	10%	2,642	0,0132	1,33E-05	0,000099	HDV
Carrier X	1	3	5%	2,642	0,024	1,33E-05	0,00056	MDV
Carrier X	2	3	5%	2,642	0,024	1,33E-05	0,00056	MDV

Table 8-1: Information Sources for Calculating Emission Profiles

Engine	Truck Type	Data	Total	Weighed AVG
3	HDV	Unit	99	
		Percentage	82,50%	
		CO2AVG	2,642	2,17965
		NOxAVG	0,0221	0,0182325
		SOxAVG	0,0000133	1,09725E-05
		PM AVG	0,000495	0,000408375
	MDV	Unit	3	
		Percentage	2,50%	
		CO2AVG	2,642	0,06605
		NOxAVG	0,024	0,0006
		SOxAVG	0,0000133	3,325E-07
		PM AVG	0,00056	0,000014
4	HDV	Unit	18	
		Percentage	15,00%	
		CO2AVG	2,642	0,3963
		NOxAVG	0,0132	0,00198
		SOxAVG	0,0000133	0,000001995
		PM AVG	0,000099	0,00001485
Total Unit			120	
Total Percentage			100,00%	
Total CO2 AVG (kg/liter)				**2,642**
Total NOx AVG (kg/liter)				**0,0208125**
Total SOx AVG (kg/liter)				**0,0000133**
Total PM AVG (kg/liter)				**0.000437225**

Table 8-2: Weighted Emission Average for Carrier X According to Percentage of Transport Work

Step 3

From Step 2 we obtain emission factors in kilograms per liter of fuel used for “Carrier X”:

Total CO2AVG (kg/liter)	**2,642**
Total NOxAVG (kg/liter)	**0,0208125**
Total SOxAVG (kg/liter)	**0,0000133**
Total PM AVG (kg/liter)	**0,0004372**

With the above information, it is possible to calculate the fuel consumption per truck using the standard NTM fuel consumption values as listed in Exhibit 8-3:

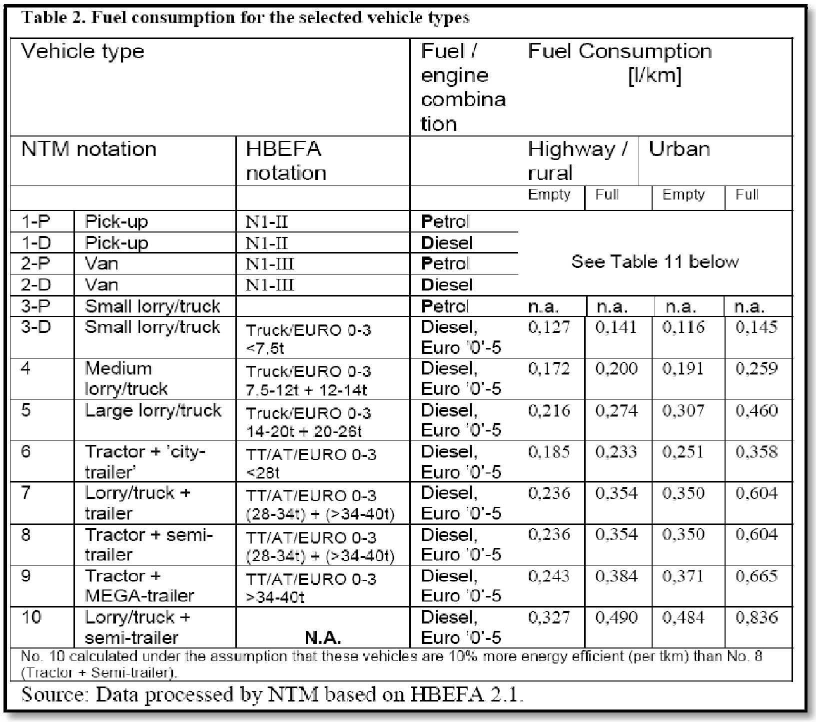


Table 2. Fuel consumption for the selected vehicle types

Vehicle type			Fuel / engine combination	Fuel Consumption [l/km]			
NTM notation		HBEFA notation		Highway / rural		Urban	
				Empty	Full	Empty	Full
1-P	Pick-up	N1-II	Petrol	See Table 11 below			
1-D	Pick-up	N1-II	Diesel				
2-P	Van	N1-III	Petrol				
2-D	Van	N1-III	Diesel				
3-P	Small lorry/truck		Petrol	n.a.	n.a.	n.a.	n.a.
3-D	Small lorry/truck	Truck/EURO 0-3 <7,5t	Diesel, Euro '0'-5	0,127	0,141	0,116	0,145
4	Medium lorry/truck	Truck/EURO 0-3 7,5-12t + 12-14t	Diesel, Euro '0'-5	0,172	0,200	0,191	0,259
5	Large lorry/truck	Truck/EURO 0-3 14-20t + 20-26t	Diesel, Euro '0'-5	0,216	0,274	0,307	0,460
6	Tractor + 'city-trailer'	TT/AT/EURO 0-3 <28t	Diesel, Euro '0'-5	0,185	0,233	0,251	0,358
7	Lorry/truck + trailer	TT/AT/EURO 0-3 (28-34t) + (>34-40t)	Diesel, Euro '0'-5	0,236	0,354	0,350	0,604
8	Tractor + semi-trailer	TT/AT/EURO 0-3 (28-34t) + (>34-40t)	Diesel, Euro '0'-5	0,236	0,354	0,350	0,604
9	Tractor + MEGA-trailer	TT/AT/EURO 0-3 >34-40t	Diesel, Euro '0'-5	0,243	0,384	0,371	0,665
10	Lorry/truck + semi-trailer	N.A.	Diesel, Euro '0'-5	0,327	0,490	0,484	0,836

No. 10 calculated under the assumption that these vehicles are 10% more energy efficient (per tkm) than No. 8 (Tractor + Semi-trailer).

Source: Data processed by NTM based on HBEFA 2.1.

Exhibit 8-3: NTM (2007) Fuel Consumption Values

Based on statistics from the ILD department, the majority of trucks used are Medium Lorry/Truck (Vehicle Type 4 or MDV), Tractor + Semitrailer / Lorry-truck + trailer (Vehicle Types 7 and 8 or HDV), and Tractor + MEGA trailer (Type 9 or MEGA). Fuel consumption values are therefore based on those configurations.

Since VLC does not possess data on driving conditions (Highway/Rural or Urban), the authors have decided to keep driving conditions consistent using the NTM Highway/Rural fuel consumption values.

Step 4

Two values are needed to finalize the carrier emission profile: (i) emissions for empty haulage and (ii) incremental emissions from every added ton of loaded cargo. The process for obtaining these values, focusing only on CO_2 emissions, is outlined below.

In order to obtain emissions for empty haulage, we multiply the average emissions factor for the carrier, in kilograms per liter, by the amount of fuel consumed per kilometer, according to empty haulage for the specific type of truck; in this case, an MDV with 0,172 l/km. The result is presented in kilograms; therefore, it must be multiplied by 1000 to obtain grams. Finally, divide this value by the cargo capacity of the truck, in this case, 16 tons. For example, to calculate CO_2 emissions from empty haulage the equation is as follows:

Equation #1: CO_2 gr/tkm - Emissions from Empty Haulage:

2.642 (kg /liter) * 0.172 (liter / km) * 1000 / 16 tons **= 28.40 grams per ton-km**

To determine incremental emissions from every additional ton of loaded cargo, the user needs to first calculate the emissions when the vehicle is fully loaded and then subtract the emissions from empty haulage. In this case, the emissions from a fully loaded vehicle are obtained using the same formula as above except the fuel consumption/km value is for a full truck. For example, to calculate CO_2 emissions at maximum fill rate, the equation is as follows:

Equation #2: CO_2 gr/tkm - Emissions Operating at Maximum Fill Rate:

2.642 (kg /liter) * 0.200 (liter / km) * 1000 / 16 tons = **33.03 grams per ton-km**

Step 5

Lastly, in order to determine incremental emissions of CO_2 per additional ton of loaded cargo, subtract the result of equation #1 from the result of equation #2:

Equation #3: CO_2 gr/tkm - Incremental per ton emissions:

33.025 g per ton-km - 28.4015 g per ton-km / 16 tons **= 0,289 grams per ton-km**

Following this five-step calculation, the user generates an individual carrier profile consisting of the carrier's average fill rate, average emissions of CO_2 for an empty loaded unit, and average incremental emissions of CO_2 per additional ton of loaded cargo.

The same process must be followed to obtain average empty loaded and incremental emission factors for NO_x, SO_x, and PM. As part of the solution proposal for VLC, this process has been automated in Excel, the results of which are displayed in the table 8-3:

	Average Emission Factor for Carrier X (kg/liter)	Cargo Capacity NTM (tons)	Fuel Usage NTM EMPTY (l/km)	Fuel Usage NTM FULL (l/km)	Empty (gr/tkm)	Increment per added ton (gr/tkm)
Total CO2AVG (kg/liter)	**2,642**	16	0,172	0,2	**28,4015**	**0,2889688**
Total NOx AVG (kg/liter)	**0,0208125**	16	0,172	0,2	**0,2237**	**0,0023**
Total SOx AVG (kg/liter)	**0,0000133**	16	0,172	0,2	**0,00014**	**0,00000145**
Total PM AVG (kg/liter)	**0,0004372**	16	0,172	0,2	**0,0047**	**0,000048**

Table 8-3: Emission Profile Calculation Process for Carrier X

The following is an example of an emissions profile generated through the five step calculation designed for use in Proxio's environmental module:

Emission Profile (gr/tkm)

Carrier Name	CO2 Empty	CO2 Increment per added ton	NOx Empty	NOx Increment per added ton	SOx Empty	SOx Increment per added ton	PM Empty	PM Increment per added ton	Fill Rate
Carrier X	28,402	0,289	0,224	0,002276	0,000143	0,000001	0,004700	0,000048	90%

Figure 8-2: Carrier Emission Profile in Proxio Environmental Module

As illustrated previously in Table 8-2, emission profiles depend on what type of vehicle (MDV, HDV, or Mega trailer) the carrier's fleet is composed of. The optimal case would therefore be to obtain three separate emission profiles per carrier according to the type of vehicle. The authors have concluded however, that given the current situation at VLC, a per carrier emission profile is sufficient. Doing otherwise would significantly increase the workload at the ILD department as they do not have the adequate IS/IT systems in place.

Once a carrier emission profile is created, the aim is to store these emission profiles in a central data warehouse. The profiles are then to be extracted for use via an online Excel reporting tool, functioning in the same way as the tool suggested for 'day-to-day shipment' data from TIR and FADS and 'tariff data' from CIC. This capability would allow VLC to efficiently increase the number of emission profiles per carrier, accounting for the various types of trucks in their fleet. This would further increase the accuracy of the emissions calculation process.

8.2.2 Proxio Environmental Module Development Process

The following section outlines the necessary steps that must be programmed into Proxio by the AB Proxio development team to enable the implementation of Proxio's environmental module. These steps include the linkage of an individual carrier emission profile to a specific carrier tariff, which provides information on vehicle capacity and distance traveled. These tariffs are subsequently linked to shipments shipped throughout the logistics network, which provide cargo specifications in volume and/or weight. This three-stage relationship is illustrated in Figure 8-3:

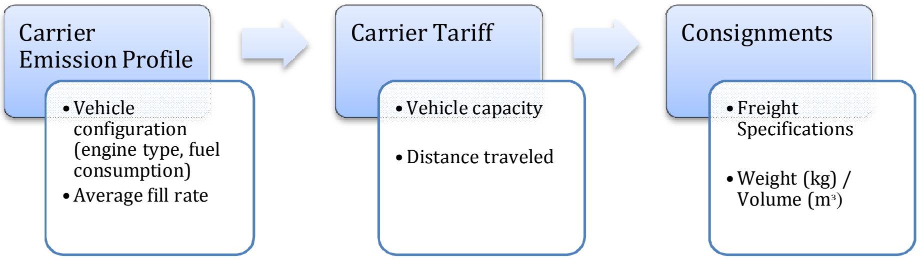


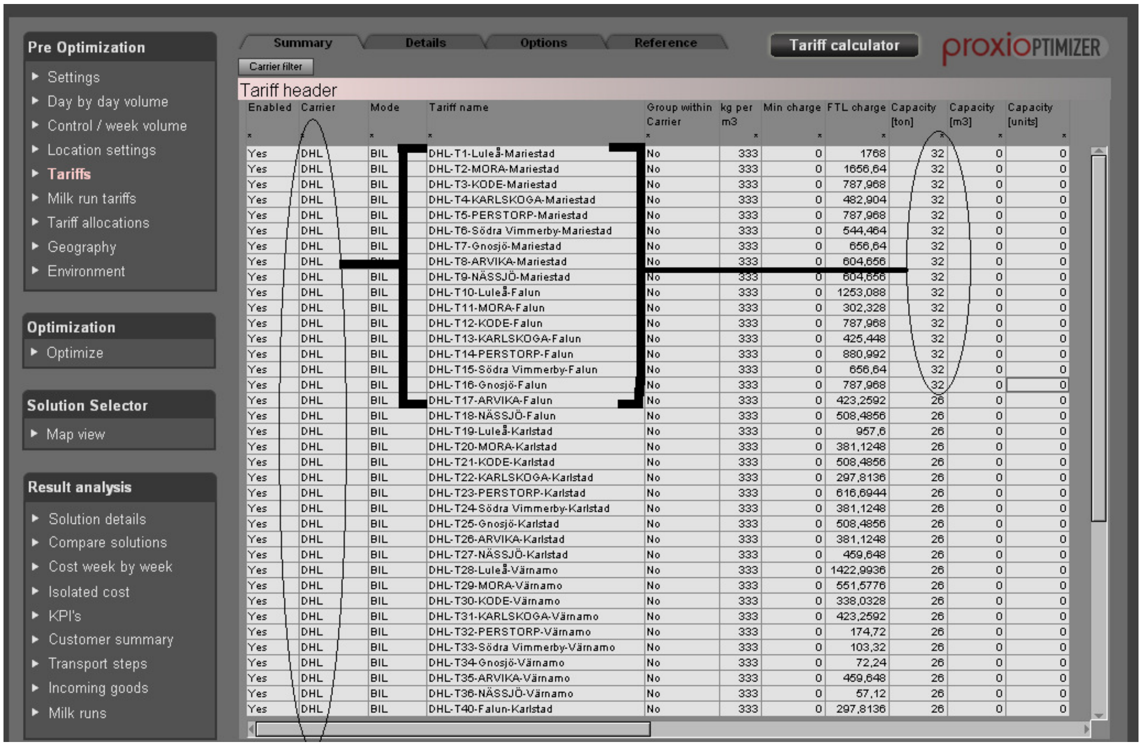
Figure 8-3: Emission Profile Data Linkage

Step 1

To begin, the user must first input the carrier emission profiles into Proxio's environmental module and name the profiles in accordance with the carrier they represent (i.e. Carrier X emission profile). Proxio refers to carrier emission profiles as 'environmental profiles.'

Step 2

The second step is to obtain *Tariff Names* (centre) that connect *Carrier Name* (left) and *Cargo Capacity* (right) as illustrated in Figure 8-4.



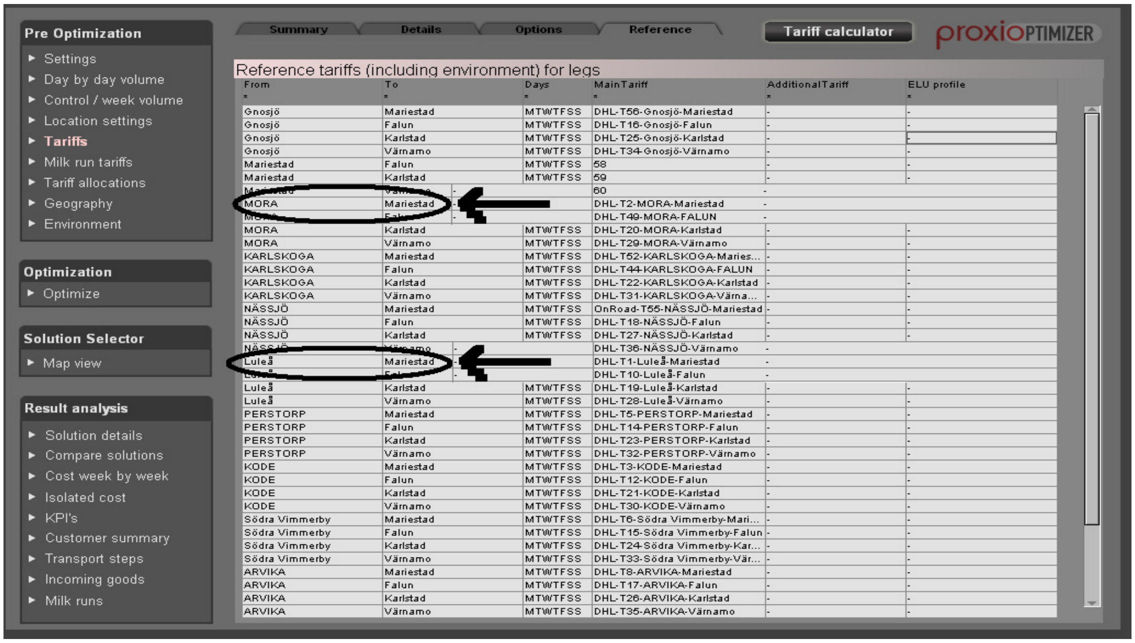
Tariff header

Enabled	Carrier	Mode	Tariff name	Group within Carrier	kg per m3	Min charge	FTL charge	Capacity [ton]	Capacity [m3]	Capacity [units]
Yes	DHL	BIL	DHL-T1-Luleå-Mariestad	No	333	0	1768	32	0	0
Yes	DHL	BIL	DHL-T2-MORA-Mariestad	No	333	0	1656,64	32	0	0
Yes	DHL	BIL	DHL-T3-KODE-Mariestad	No	333	0	787,968	32	0	0
Yes	DHL	BIL	DHL-T4-KARLSKOGA-Mariestad	No	333	0	482,904	32	0	0
Yes	DHL	BIL	DHL-T5-PERSTORP-Mariestad	No	333	0	787,968	32	0	0
Yes	DHL	BIL	DHL-T6-Södra Vimmerby-Mariestad	No	333	0	544,464	32	0	0
Yes	DHL	BIL	DHL-T7-Gnosjö-Mariestad	No	333	0	656,64	32	0	0
Yes	DHL	BIL	DHL-T8-ARVIKA-Mariestad	No	333	0	604,656	32	0	0
Yes	DHL	BIL	DHL-T9-NÄSSJÖ-Mariestad	No	333	0	604,656	32	0	0
Yes	DHL	BIL	DHL-T10-Luleå-Falun	No	333	0	1253,088	32	0	0
Yes	DHL	BIL	DHL-T11-MORA-Falun	No	333	0	302,328	32	0	0
Yes	DHL	BIL	DHL-T12-KODE-Falun	No	333	0	787,968	32	0	0
Yes	DHL	BIL	DHL-T13-KARLSKOGA-Falun	No	333	0	425,448	32	0	0
Yes	DHL	BIL	DHL-T14-PERSTORP-Falun	No	333	0	880,992	32	0	0
Yes	DHL	BIL	DHL-T15-Södra Vimmerby-Falun	No	333	0	656,64	32	0	0
Yes	DHL	BIL	DHL-T16-Gnosjö-Falun	No	333	0	787,968	32	0	0
Yes	DHL	BIL	DHL-T17-ARVIKA-Falun	No	333	0	423,2592	26	0	0
Yes	DHL	BIL	DHL-T18-NÄSSJÖ-Falun	No	333	0	508,4856	26	0	0
Yes	DHL	BIL	DHL-T19-Luleå-Karlstad	No	333	0	957,6	26	0	0
Yes	DHL	BIL	DHL-T20-MORA-Karlstad	No	333	0	381,1248	26	0	0
Yes	DHL	BIL	DHL-T21-KODE-Karlstad	No	333	0	508,4856	26	0	0
Yes	DHL	BIL	DHL-T22-KARLSKOGA-Karlstad	No	333	0	297,8136	26	0	0
Yes	DHL	BIL	DHL-T23-PERSTORP-Karlstad	No	333	0	616,6944	26	0	0
Yes	DHL	BIL	DHL-T24-Södra Vimmerby-Karlstad	No	333	0	381,1248	26	0	0
Yes	DHL	BIL	DHL-T25-Gnosjö-Karlstad	No	333	0	508,4856	26	0	0
Yes	DHL	BIL	DHL-T26-ARVIKA-Karlstad	No	333	0	381,1248	26	0	0
Yes	DHL	BIL	DHL-T27-NÄSSJÖ-Karlstad	No	333	0	459,648	26	0	0
Yes	DHL	BIL	DHL-T28-Luleå-Värnamo	No	333	0	1422,9936	26	0	0
Yes	DHL	BIL	DHL-T29-MORA-Värnamo	No	333	0	551,5776	26	0	0
Yes	DHL	BIL	DHL-T30-KODE-Värnamo	No	333	0	338,0328	26	0	0
Yes	DHL	BIL	DHL-T31-KARLSKOGA-Värnamo	No	333	0	423,2592	26	0	0
Yes	DHL	BIL	DHL-T32-PERSTORP-Värnamo	No	333	0	174,72	26	0	0
Yes	DHL	BIL	DHL-T33-Södra Vimmerby-Värnamo	No	333	0	103,32	26	0	0
Yes	DHL	BIL	DHL-T34-Gnosjö-Värnamo	No	333	0	72,24	26	0	0
Yes	DHL	BIL	DHL-T35-ARVIKA-Värnamo	No	333	0	459,648	26	0	0
Yes	DHL	BIL	DHL-T36-NÄSSJÖ-Värnamo	No	333	0	57,12	26	0	0
Yes	DHL	BIL	DHL-T40-Falun-Karlstad	No	333	0	297,8136	26	0	0

Figure 8-4: Proxio Screenshot, Linkage of Carrier Name with Tariff and Cargo Capacity

Step 3

In step three, *Tariff Names* located in 'Tariff Summary' are to be linked to the *From-To Locations* located in 'Tariff Reference' as illustrated in Figure 8-5.



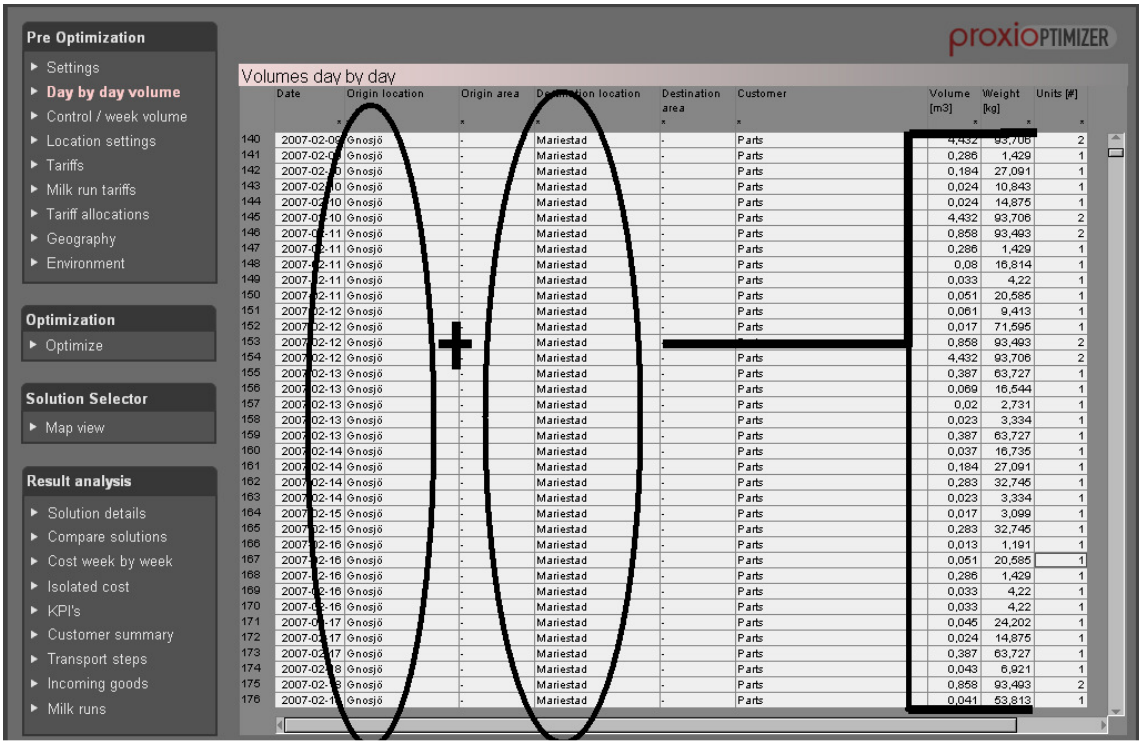
Reference tariffs (including environment) for legs

From	To	Days	MainTariff	AdditionalTariff	ELU profile
Gnosjö	Mariestad	MTWTFSS	DHL-T56-Gnosjö-Mariestad	-	-
Gnosjö	Falun	MTWTFSS	DHL-T16-Gnosjö-Falun	-	-
Gnosjö	Karlstad	MTWTFSS	DHL-T25-Gnosjö-Karlstad	-	-
Gnosjö	Värnamo	MTWTFSS	DHL-T34-Gnosjö-Värnamo	-	-
Mariestad	Falun	MTWTFSS	58	-	-
Mariestad	Karlstad	MTWTFSS	59	-	-
Mariestad	Värnamo	-	60	-	
MORA	Mariestad	-	DHL-T2-MORA-Mariestad	-	
MORA	Falun	-	DHL-T49-MORA-FALUN	-	
MORA	Karlstad	MTWTFSS	DHL-T20-MORA-Karlstad	-	-
MORA	Värnamo	MTWTFSS	DHL-T29-MORA-Värnamo	-	-
KARLSKOGA	Mariestad	MTWTFSS	DHL-T52-KARLSKOGA-Maries...	-	-
KARLSKOGA	Falun	MTWTFSS	DHL-T44-KARLSKOGA-FALUN	-	-
KARLSKOGA	Karlstad	MTWTFSS	DHL-T22-KARLSKOGA-Karlstad	-	-
KARLSKOGA	Värnamo	MTWTFSS	DHL-T31-KARLSKOGA-Värna...	-	-
NÄSSJÖ	Mariestad	MTWTFSS	OnRoad-T55-NÄSSJÖ-Mariestad	-	-
NÄSSJÖ	Falun	MTWTFSS	DHL-T18-NÄSSJÖ-Falun	-	-
NÄSSJÖ	Karlstad	MTWTFSS	DHL-T27-NÄSSJÖ-Karlstad	-	-
NÄSSJÖ	Värnamo	-	DHL-T36-NÄSSJÖ-Värnamo	-	
Luleå	Mariestad	-	DHL-T1-Luleå-Mariestad	-	
Luleå	Falun	-	DHL-T10-Luleå-Falun	-	
Luleå	Karlstad	MTWTFSS	DHL-T19-Luleå-Karlstad	-	-
Luleå	Värnamo	MTWTFSS	DHL-T28-Luleå-Värnamo	-	-
PERSTORP	Mariestad	MTWTFSS	DHL-T5-PERSTORP-Mariestad	-	-
PERSTORP	Falun	MTWTFSS	DHL-T14-PERSTORP-Falun	-	-
PERSTORP	Karlstad	MTWTFSS	DHL-T23-PERSTORP-Karlstad	-	-
PERSTORP	Värnamo	MTWTFSS	DHL-T32-PERSTORP-Värnamo	-	-
KODE	Mariestad	MTWTFSS	DHL-T3-KODE-Mariestad	-	-
KODE	Falun	MTWTFSS	DHL-T12-KODE-Falun	-	-
KODE	Karlstad	MTWTFSS	DHL-T21-KODE-Karlstad	-	-
KODE	Värnamo	MTWTFSS	DHL-T30-KODE-Värnamo	-	-
Södra Vimmerby	Mariestad	MTWTFSS	DHL-T6-Södra Vimmerby-Mari...	-	-
Södra Vimmerby	Falun	MTWTFSS	DHL-T15-Södra Vimmerby-Falun	-	-
Södra Vimmerby	Karlstad	MTWTFSS	DHL-T24-Södra Vimmerby-Kar...	-	-
Södra Vimmerby	Värnamo	MTWTFSS	DHL-T33-Södra Vimmerby-Vär...	-	-
ARVIKA	Mariestad	MTWTFSS	DHL-T8-ARVIKA-Mariestad	-	-
ARVIKA	Falun	MTWTFSS	DHL-T17-ARVIKA-Falun	-	-
ARVIKA	Karlstad	MTWTFSS	DHL-T26-ARVIKA-Karlstad	-	-
ARVIKA	Värnamo	MTWTFSS	DHL-T35-ARVIKA-Värnamo	-	-

Figure 8-5: Proxio Screenshot, Linkage of Tariff Names with From-To Locations

Step 4

Step four requires that *From-To Locations* located in 'Tariff Reference' are linked to *From-To Locations* in 'Day-By-Day volume.' This is necessary in order to obtain the per shipment weights and volumes illustrated below on the right side of Figure 8-6.



Volumes day by day

	Date	Origin location	Origin area	Destination location	Destination area	Customer	Volume [m3]	Weight [kg]	Units [#]
140	2007-02-09	Gnosjö	-	Mariestad	-	Parts	4,432	93,706	2
141	2007-02-09	Gnosjö	-	Mariestad	-	Parts	0,286	1,429	1
142	2007-02-10	Gnosjö	-	Mariestad	-	Parts	0,184	27,091	1
143	2007-02-10	Gnosjö	-	Mariestad	-	Parts	0,024	10,843	1
144	2007-02-10	Gnosjö	-	Mariestad	-	Parts	0,024	14,875	1
145	2007-02-10	Gnosjö	-	Mariestad	-	Parts	4,432	93,706	2
146	2007-02-11	Gnosjö	-	Mariestad	-	Parts	0,858	93,493	2
147	2007-02-11	Gnosjö	-	Mariestad	-	Parts	0,286	1,429	1
148	2007-02-11	Gnosjö	-	Mariestad	-	Parts	0,08	16,814	1
149	2007-02-11	Gnosjö	-	Mariestad	-	Parts	0,033	4,22	1
150	2007-02-11	Gnosjö	-	Mariestad	-	Parts	0,051	20,585	1
151	2007-02-12	Gnosjö	-	Mariestad	-	Parts	0,061	9,413	1
152	2007-02-12	Gnosjö	-	Mariestad	-	Parts	0,017	71,595	1
153	2007-02-12	Gnosjö	-	Mariestad	-	Parts	0,858	93,493	2
154	2007-02-12	Gnosjö	-	Mariestad	-	Parts	4,432	93,706	2
155	2007-02-13	Gnosjö	-	Mariestad	-	Parts	0,387	63,727	1
156	2007-02-13	Gnosjö	-	Mariestad	-	Parts	0,069	16,544	1
157	2007-02-13	Gnosjö	-	Mariestad	-	Parts	0,02	2,731	1
158	2007-02-13	Gnosjö	-	Mariestad	-	Parts	0,023	3,334	1
159	2007-02-13	Gnosjö	-	Mariestad	-	Parts	0,387	63,727	1
160	2007-02-14	Gnosjö	-	Mariestad	-	Parts	0,037	16,735	1
161	2007-02-14	Gnosjö	-	Mariestad	-	Parts	0,184	27,091	1
162	2007-02-14	Gnosjö	-	Mariestad	-	Parts	0,283	32,745	1
163	2007-02-14	Gnosjö	-	Mariestad	-	Parts	0,023	3,334	1
164	2007-02-15	Gnosjö	-	Mariestad	-	Parts	0,017	3,099	1
165	2007-02-15	Gnosjö	-	Mariestad	-	Parts	0,283	32,745	1
166	2007-02-16	Gnosjö	-	Mariestad	-	Parts	0,013	1,191	1
167	2007-02-16	Gnosjö	-	Mariestad	-	Parts	0,051	20,585	1
168	2007-02-16	Gnosjö	-	Mariestad	-	Parts	0,286	1,429	1
169	2007-02-16	Gnosjö	-	Mariestad	-	Parts	0,033	4,22	1
170	2007-02-16	Gnosjö	-	Mariestad	-	Parts	0,033	4,22	1
171	2007-02-17	Gnosjö	-	Mariestad	-	Parts	0,045	24,202	1
172	2007-02-17	Gnosjö	-	Mariestad	-	Parts	0,024	14,875	1
173	2007-02-17	Gnosjö	-	Mariestad	-	Parts	0,387	63,727	1
174	2007-02-18	Gnosjö	-	Mariestad	-	Parts	0,043	6,921	1
175	2007-02-18	Gnosjö	-	Mariestad	-	Parts	0,858	93,493	2
176	2007-02-18	Gnosjö	-	Mariestad	-	Parts	0,041	53,813	1

Figure 8-6: Proxio Screenshot, Linkage of From-To location with Shipment Weights and Volumes

Once the linkages in Proxio have been programmed, the Proxio environmental module can calculate total emissions from all the transport work conducted by the carrier under the given tariff based on the carrier's emission profile (see example 1 below). The module then allocates the correct proportion of total produced emissions to VLC's freight based on VLC's share of cargo emission + VLC's share of empty haulage emissions + VLC's share of unused cargo capacity. This calculation is illustrated in the following example:

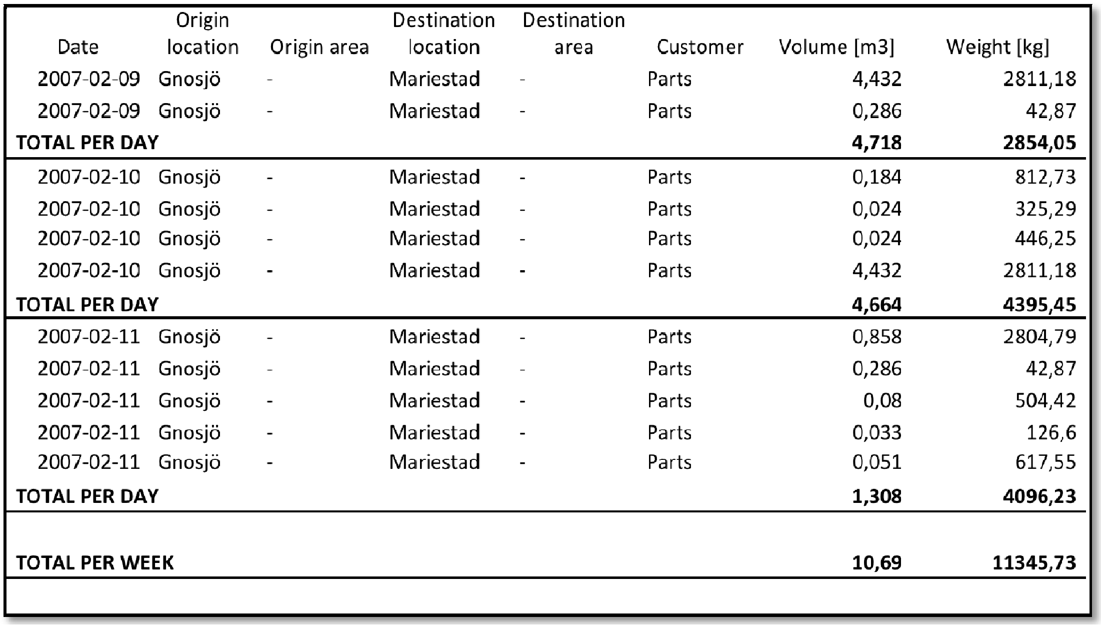
Example 1: Total Emissions Calculation Example

This section outlines the calculation process Proxio follows in order to obtain total emissions. The following example focuses on calculating total NOx produced from a weekly cargo load of 11 345,73 kg (obtained from statistics in Figure 8-7) on a 16 ton truck, and a 90% fill rate including our goods. We begin by obtaining the carrier emission profile:

Emission Profile (gr/tkm)

Carrier Name	CO_2 Empty	CO_2 Increment per added ton	NOx Empty	NOx Increment per added ton	SOx Empty	SOx Increment per added ton	PM Empty	PM Increment per added ton	Fill Rate
Carrier X	28,402	0,289	0,224	0,002276	0,000143	0,000001	0,004700	0,000048	90%

Next, we retrieve VLC's total shipment weight from the previous week which is located in 'Day-by-Day volume' statistics in Proxio as illustrated in Figure 8-7:



Date	Origin location	Origin area	Destination location	Destination area	Customer	Volume [m3]	Weight [kg]
2007-02-09	Gnosjö	-	Mariestad	-	Parts	4,432	2811,18
2007-02-09	Gnosjö	-	Mariestad	-	Parts	0,286	42,87
TOTAL PER DAY						**4,718**	**2854,05**
2007-02-10	Gnosjö	-	Mariestad	-	Parts	0,184	812,73
2007-02-10	Gnosjö	-	Mariestad	-	Parts	0,024	325,29
2007-02-10	Gnosjö	-	Mariestad	-	Parts	0,024	446,25
2007-02-10	Gnosjö	-	Mariestad	-	Parts	4,432	2811,18
TOTAL PER DAY						**4,664**	**4395,45**
2007-02-11	Gnosjö	-	Mariestad	-	Parts	0,858	2804,79
2007-02-11	Gnosjö	-	Mariestad	-	Parts	0,286	42,87
2007-02-11	Gnosjö	-	Mariestad	-	Parts	0,08	504,42
2007-02-11	Gnosjö	-	Mariestad	-	Parts	0,033	126,6
2007-02-11	Gnosjö	-	Mariestad	-	Parts	0,051	617,55
TOTAL PER DAY						**1,308**	**4096,23**
TOTAL PER WEEK						**10,69**	**11345,73**

Figure 8-7: Example of Day-by-Day Volume Statistics in Proxio

We then apply the following emissions calculation equation, which takes into consideration VLC's share of cargo (equation 2).

VLC's Share of Loaded Emission	**+**	**VLC's Share of Empty Haulage Emissions**	**+**	**VLC's Share of Unused Cargo Capacity on Truck**
Weight of VLC Goods * Incremental		Weight of VLC Goods * Empty Emissions		(VLC Fill Rate) / (Carrier Fill Rate - VLC Fill Rate) * Empty Emissions of VLC Goods
11,345(t) * 0,002276 gr/tkm	+	11,345(t)/16(t) * 0,224 gr/tkm	+	(11,345t/16t)/((,90) - (11,345t/16t)) * 0,224 gr/tkm
0,025821 gr/tkm	+	0,15883 gr/tkm	+	0,831843 gr/tkm
= 1.016 grams of NOx per km				

Equation 2: Emissions Calculation Equation

Finally, in order to evaluate the external, environmental cost of these emissions the total NOx of 1.016 grams per km would be multiplied by the corresponding monetary value of €4400 per ton of NOx as established in the IMPACT study and illustrated in Table 8-4. An external environmental cost figure would then be obtained which can be integrated into the logistics network decision making process alongside internal costs.

Emissions Valuation of NOx per km

€ 4400/1 000 000 * 1.016494 = **0.00448 € per km**

Euros/ton (EU-25 Avg. 2008)			
	NOx	***SOx***	***PM***
Euros (€)	4400	5600	26000

Euros/ton CO2 (EU-25)			
Year of application	Lower Value (€)	Central Value (€)	Upper Value (€)
2010	7	25	45
2020	17	40	70
2030	22	55	100
2040	22	70	135
2050	20	85	180

Table 8-4: Impact Study, Estimation of External Costs in the Transport Sector (IMPACT 2008)

8.2.3 Calculating Efficiencies from Freight Consolidation in Proxio

By generating individualized carrier emission profiles, Proxio's environmental module can obtain a measure of efficiency by calculating the decrease in incremental emissions per ton-km derived from increasing the fill rate of the load unit. As modeled in Table 8-4 and the corresponding Figure 8-8, significant reductions in emissions per ton-km can be accounted for using the emission profiles input into Proxio (example for MDV-type truck travelling 1 km):

	Total Emissions (gr/tkm)				Efficiency in Emissions per Ton (gr/tkm)			
Cargo (tons)	CO2	NOx	SOx	PM	CO2	NOx	SOx	PM
0	28,4	0,2237	0,00014	0,0047	28,4	0,2237	0,00014	0,0047
1	28,69	0,226	0,000141	0,004748	28,69	0,2260	0,000141	0,004748
2	28,98	0,2283	0,000143	0,004796	14,49	0,1142	7,15E-05	0,002398
3	29,27	0,2306	0,000144	0,004844	9,76	0,0769	4,81E-05	0,001615
4	29,56	0,2329	0,000146	0,004892	7,39	0,0582	3,65E-05	0,001223
5	29,85	0,2352	0,000147	0,00494	5,97	0,0470	2,95E-05	0,000988
6	30,14	0,2375	0,000149	0,004988	5,02	0,0396	2,48E-05	0,000831
7	30,42	0,2398	0,00015	0,005036	4,35	0,0343	2,15E-05	0,000719
8	30,71	0,2421	0,000152	0,005084	3,84	0,0303	1,9E-05	0,000636
9	31	0,2444	0,000153	0,005132	3,44	0,0272	1,7E-05	0,00057
10	31,29	0,2467	0,000155	0,00518	3,13	0,0247	1,55E-05	0,000518
11	31,58	0,249	0,000156	0,005228	2,87	0,0226	1,42E-05	0,000475
12	31,87	0,2513	0,000157	0,005276	2,66	0,0209	1,31E-05	0,00044
13	32,16	0,2536	0,000159	0,005324	2,47	0,0195	1,22E-05	0,00041
14	32,45	0,2559	0,00016	0,005372	2,32	0,0183	1,15E-05	0,000384
15	32,74	0,2582	0,000162	0,00542	2,18	0,0172	1,08E-05	0,000361
16	33,03	0,2605	0,000163	0,005468	2,06	0,0163	1,02E-05	0,000342

Table 8-4: Emissions Efficiencies

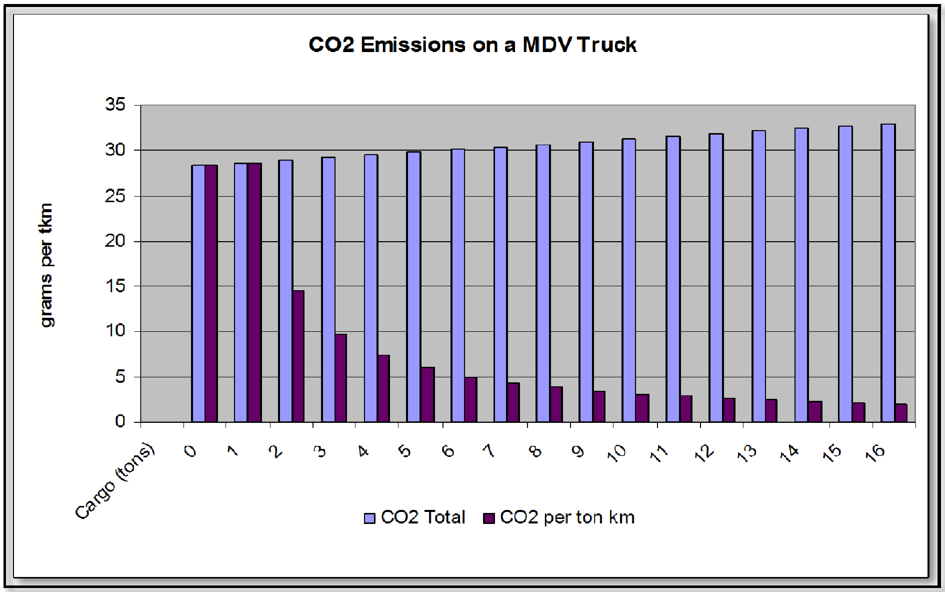


Figure 8-8: Model of Increasing Efficiency Derived from Increased Carrier Fill Rate

8.3 Information Output

Once Proxio has produced an optimized network schedule, the data is exported onto a reporting template where it is automatically interpreted and a standardized report is made. This report presents information to decision makers regarding internal (monetary) and external (emissions) cost figures, and a comparison between:

i. Optimized set-ups from previous periods if used by the Core Values department.
ii. Optimized set-ups from different network configurations if used by the ILD department.

This report also compares several set-ups according to total transport cost, total emissions, total external environmental cost (according to the monetary values established for emissions in the IMPACT study), emissions per unit produced, emissions by supplier country of origin, and the top ten carriers by cost and by emissions. This will allow management to locate which routes and flows have the biggest impact on total emissions and take corrective action. An example of this report can be seen in Appendix 8.

Once Proxio has produced an optimized network schedule and the reporting function has presented the customer with the information as outlined above, the customer will give its feedback to the ILD department. If the network configuration is approved, it will then be implemented accordingly. The implementation of the network is, however, outside the scope of this thesis.

8.4 Solution Proposal Summary

The solution proposed to VLC to improve the production of EIAs and the subsequent integration of environmental cost information in logistics network management requires a focus on three elements: (i) People (ii) Processes (iii) Technology. Exhibit 8-4 presents a summary of the solution proposal along with several key success factors:

Solution Proposal Summary

People

- Basic Education on Volvo Logistics' Ecological Footprint
- Training in Emissions Calculations and New IT Applications
- Improved Data Quality
- Feedback on Environmental Performance Following Training Programs

Process

- Synchronize Emissions Forecasts and Logistics Cost Calculations
- Standardized Data Extraction Process for ILD and Emissions Reporting
- Redesign Emissions Reporting Process

Technology

- *Input*
    - Data Quality
        - Central Data Warehouse
        - Euro FOT
    - Streamline and Standardize Data Extraction Process
        - Data from Customers
        - Data from Database Systems
        - Data Format
- *Analysis*
    - Generate Emission Profiles
    - Input Emission Profiles into Proxio and Link to Carrier Tariffs
    - Calculate Efficiencies from Freight Consolidation in Proxio
- *Output*
    - Transport Schedule with Forecasted Emissions
    - Standardized Internal (Monetary) and External (Emissions) Cost Reports

Key Success Factors

- Senior Executive Support, Involvement, and Leadership
- A well-Defined Strategic Vision, and Action Plan
- Organization-Wide Awareness of Environmental Issues
- A Baseline from which Performance can be Measured Over Time
- Clearly Defined Procedures for Internal Communication and External Reporting
- Rigorous Application of Emissions Calculation Methodology
- Lean Systems Concept
- Continuous Process Improvement
- Constructive Feedback and Updates on Progress Towards Environmental Targets
- Environmental Performance Targets

Exhibit 8-4: Solution Proposal Summary and Key Success Factors

"It is not necessary to change. Survival is not mandatory."

— W. Edwards Deming

Chapter 9:

Conclusion

This chapter summarizes the thesis objective and answers each of the research questions. It also includes a discussion about the project's future development and continuous improvement at Volvo Logistics. Lastly, the authors present their recommendations for future research in the field of logistics management.

Chapter Outline

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9.1 Final Remarks

This thesis presented an outline of the proposed improvements in VLC's people, processes, and technologies that are needed in order to integrate environmental cost information in logistics network management.

The objective of this thesis was two fold: (i) to develop a system capable of providing environmental cost information to decision makers at Volvo Logistics in a timely and effective manner in order to incorporate emission levels as a key performance indicator in logistics network management and (ii) to conduct scientific research which meets the requirements of the academic community and produces new knowledge regarding the integration of environmental cost information in logistics network management. To fulfill both of these objectives, the authors had to explore, describe, and explain the challenges and constraints behind the problem before beginning the development of a practical solution and new academic knowledge. Over the course of three months, the authors conducted qualitative research at Volvo Logistics, which involved an interdisciplinary focus on environmental sciences, logistics management, and information systems/information technology.

Working as consultants for Volvo Logistics, the goal was to promptly and efficiently devise a practical solution to the business problem. On the other hand, as academic researchers, the priority was to craft a robust and comprehensive research methodology in order to fulfill the requirements of the academic community.

As noted in Chapter 1, the authors derived the following research question from the challenge facing VLC: *How can we develop an IS/IT solution that will quantify, record, analyze, and effectively and efficiently communicate emission levels for logistics network design and emissions accounting reports?* This research question was then broken down into five sub-questions, which formed the foundation of the solution.

In answering the first research question, *how can we accurately quantify emissions?*, the authors elected to employ the NTM methodology. It is important to note that case specific data on a per carrier, per shipment basis should be used whenever possible. Of course, industry averages provided by NTM will suffice, but the more case specific data one has access to, the more valid and reliable the quantified emission levels will be.

To address the second research question, *how can we record and store emissions data?,* the researchers explored academic and industry literature as well as the current database systems at Volvo Logistics. Since environmental care is a Core Value at Volvo Logistics, it was revealing to discover that emissions data, such as carrier emission profiles and fill rates, are not recorded in any way except for the annual carrier survey, and are not stored in any of the existing database systems. The authors proposed that emissions data should be recorded on a more continuous basis and stored in a dedicated database. This would facilitate the collection of higher quality, more robust data, as well as the extraction and sharing of emissions data between members of the organization and their customers.

The third question, *how can we properly analyze this data to extract valuable information?,* was related to the analysis of emissions and other environmental performance data once it has been quantified and stored. The authors propose three methods of analyzing data:

(i) Compare absolute emission levels to a benchmarked base year
(ii) Apply the Environmental Load Unit (ELU) of measurement
(iii) Apply a monetary value to emissions based on the IMPACT study

The authors propose the use of the IMPACT study's average monetary emission values as part of the solution for VLC. For companies looking to implement an emissions reduction strategy, establishing a base year level and then comparing high level estimates of total emissions from subsequent years is the first step. In regards to IT applications used to analyze emission levels at VLC, the authors studied EnvCalc and Proxio. EnvCalc was proven to be a linear emissions calculating tool and was incapable of meeting the increased demands for emissions analysis at VLC. As outlined in Chapter 8, Proxio comprises a large part of the solution for VLC; thus, the authors worked in cooperation with AB Proxio to develop Proxio's environmental module throughout the thesis.

The fourth research question was: *how can we effectively communicate results internally and externally?* In answering this question, the authors developed an automated Excel reporting template that is able to compare several optimized set-ups according to total transport cost, total emissions, total emissions cost according to the monetary values established for emissions in the IMPACT study, emissions per unit produced, emissions by supplier country of origin, and the top ten carriers by cost and by emissions. This template will allow management to pinpoint which routes and flows are the largest contributors to total emissions. The goal when communicating results is to present emission levels in the right context, and with the right performance metrics. This enables the individuals whom are receiving the emission reports to understand the information and use it to make well-informed decisions. The authors also suggest the implementation of organization-wide training in basic environmental performance issues to encourage employees and managers to integrate Volvo's environmental policy into their day-to-day operations.

Lastly, the fifth research question was: *what organizational transformations need to occur in order to ensure lasting efficacy?* The answer to this question is summarized in Chapter 8, section 4 under Key Success Factors (KSFs). To recap, the KSFs to the proposed solution at VLC are:

- Senior executive support, involvement, and leadership
- A well-defined strategic vision and action plan
- A baseline from which performance can be measured over time
- Organization-wide awareness of environmental issues
- Clearly defined procedures for internal communication and external reporting
- Rigorous application of emissions recording and calculation methodology
- Continuous improvement process

9.2 Discussion

The application of the lean systems concept to the development of people, processes, and technology has led to the proposed redesign of VLC's current inbound logistics development and emissions reporting processes. In addition, an overhaul of its inbound IS/IT infrastructure and human resource training in order to meet the increasing demand for EIAs is also recommended.

This solution will enable the simultaneous calculation of forecasted financial cost and environmental cost information during the inbound logistics network development process. Possessing this information will enable VLC management and their customers to make better-informed decisions regarding the performance of their logistics networks. At the same time, the solution has been developed for use by the Environmental Core Values department to dramatically improve the emissions reporting process.

The scope of this thesis does not include the implementation of the proposed solution; however, it does lay the groundwork. In accordance with the lean systems concept, the authors strongly advise that once implemented, the solution be accompanied by a continuous improvement process based on the Deming Wheel model as illustrated in Figure 9-1. In the figure, the boxes behind the PDSA cycle represent the functions behind the proposed solution and are included to symbolize their involvement in the continuous improvement process. This is necessary in order to ensure that the process of performing EIAs and integrating environmental cost information in logistics network management continues to improve and become more efficient over time.

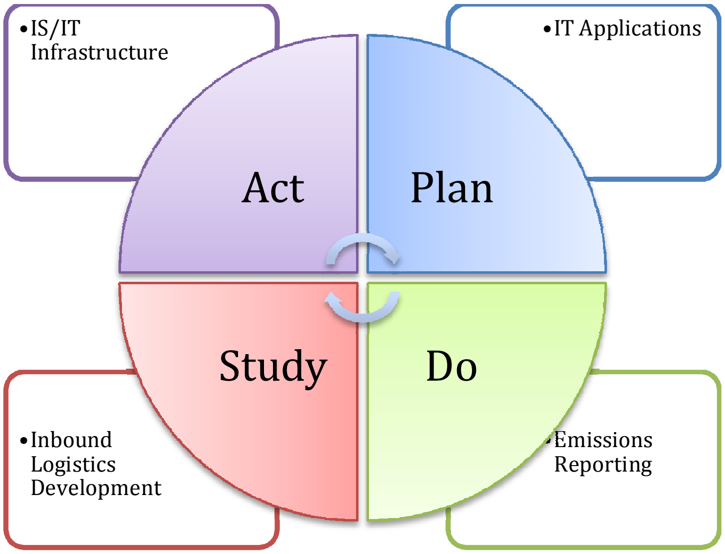

Figure 9-1: The Deming Wheel Continuous Improvement Process (Deming 1989)

9.3 Future Research and Development

The field of environmental logistics presents many interesting areas for future research and development. Of particular interest and importance to the authors is the collection of situation specific data on carrier performance. It was noted in Chapter 8 that technological developments are currently underway which will allow for the measurement of case specific carrier performance, thereby eliminating the need to rely on high-level industry averages. The implementation of this type of technology throughout Volvo Logistics' carrier network would allow for the collection of reliable case specific environmental performance data. This is an interesting concept and is an attractive avenue for future research by both the logistics industry and the academic community.

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Appendix

Appendix 1 – Volvo Group Environmental Policy

Volvo Environmental Policy

Environmental Care is one of Volvo's Core Values. The Volvo Group is a leader in terms of Environmental Care among the world's top producers of transport related products, equipment and systems. The environmental programs shall be characterized by holistic view, continual improvement, technical development and resource efficiency. The Volvo Group will by these means gain competitive advantage and contribute to sustainable development.

Holistic View
In our efforts to reduce environmental impact from our products, operations and services we shall:

- take account of the complete life cycle
- take a leading position regarding environmental care, wherever in the world we operate, with applicable legislation and other regulations as a minimum standard
- make pollution prevention a prerequisite for all operations
- encourage suppliers, dealers and other business partners within our sphere of influence to adopt the principles in this policy

Continual Improvement
Our environmental activities shall be integrated in all operations and be improved continually by:

- formulating, communicating and monitoring clearly-defined goals
- involving our employees

Technical Development
We shall strive to exceed demands and expectations from our customers and society by:

- active and future-oriented research and development efforts
- developing transport solutions with low environmental impact
- promoting development of harmonized legal requirements
- continually reducing our products' fuel consumption, exhaust emissions, noise and impact on climate change
- reducing the use of environmentally harmful materials

Resource Efficiency
Taking account of the complete life cycle, our products and industrial operations shall be such that:

- consumption of energy and raw materials is minimized
- production of waste and residual products is minimized, and waste management is facilitated

The environmental programmes and their results shall be communicated in an open and factual manner. Business areas and business units are responsible for implementing action programmes based on this Policy.

24 March 2004
Leif Johansson
President of AB Volvo and CEO

Appendix 2 – Volvo C0$_2$ Challenge

The Volvo CO_2 Challenge

As the lead logistics provider for the entire Volvo Group, VLC has accepted a CO_2 challenge from one of its major customers, Volvo Trucks, to reduce the emissions of carbon dioxide (CO_2) from road transports in Europe by 20% between 2006 and 2010. This challenge is now supported by all members of the Volvo Group and Volvo Cars. VLC has stretched this challenge from road transports to all land transport including the short sea transports from Eurobridge and Anglobridge.

The objective of the challenge is to reduce the emissions of CO_2 for land and short sea transports from Eurobridge and Anglobridge in Europe by 20% per ton-km in 2010 compared to the 2006 baseline. The reduction of the emissions measured in ton per period and defining the quantity of this reduction, is also one of the objectives of this project. Reducing the CO_2 emissions per ton-km can be measured via the results from the yearly carrier survey. The total objective can be split per year into following reductions of CO_2 on land transports and on Eurobridge and Anglobridge short sea transports in Europe:

- 2007 -3%
- 2008 -5%
- 2009 -5%
- 2010 -6%

Appendix 3 – List of Interviews Conducted

#	Informant	Position	Date	Subject
1	Agneta Carlsson	VLC Environmental Core Values Analyst	26-Jan-09	VLC Problem Formulation
2	Mattias Bergström	AB Proxio Co-Founder	02-Feb-09	Proxio Training Session
3	Henrik Erkfeldt	VLC IT Project Manager	17-Feb-09	Volvo Logistics IS/IT Infrastructure
4	Eva Gustavsson	Gothenburg University Researcher	25-Feb-09	Research Methods, Thesis Structure
5	Per Palm	VLC Logistics Development Department Analyst	27-Feb-09	Inbound Logistics Development
6	Lennart Nyström	Volvo IT Consultant	02-Mar-09	VLC IS/IT Infrastructure Layout, Data Extraction
7	Henrikke Baumann	Chalmers University of Technology Environmental Department Researcher	03-Mar-09	Emissions Calculation Methodologies, Corporate Social Responsibility
8	Gina Hernefjord	VLC Purchasing Department Contractor	03-Mar-09	VLC Purchasing Process
9	Agneta Carlsson #2	Environmental Core Values Department, Core Values Analyst	04-Mar-09	Emissions Reporting Process
10	Mattias Bergström #2	AB Proxio Co-Founder	09-Mar-09	Environmental Module Development
11	Agneta Carlsson #3	Environmental Core Values Department, Core Values Analyst	27-Mar-09	Inbound Logistics Information Flows
12	Anders Bergström	VLC Carrier Contract Manager	31-Mar-09	VLC Carrier Contracting Process
13	Lena Nordström	VLC Global Key Account Manager	01-Apr-09	VLC's Inbound Logistics Operations
14	Susanna Hambeson	VLC Environmental Manager	04-Apr-09	VLC Environmental Policy, $C0_2$ Challenge
15	Per Palm #2	VLC Logistics Development Department Analyst	04-Apr-09	Network Optimization with Proxio
16	Mattias Bergström #3	AB Proxio Co-Founder	20-Apr-09	Environmental Module Implementation
17	Lisbeth Dahllöf	Volvo Technology Environmental Engineer	22-Apr-09	External Costs Evaluation
18	Lennart Nyström	Volvo IT Consultant	14-May-09	VLC IS/IT Infrastructure Layout, Data Extraction
19	Susanna Hambeson	VLC Environmental Manager	20-May-09	Environmental Training and Education

Appendix 4 – Road Transport Sector Environmental Initiatives

Internal Initiatives	
Technical Enhancements	Comprises development of more fuel efficient and emission reducing engines (e.g. Euro I - VI class engines) as well as reducing air and rolling resistance in the vehicle.
Fuel Enhancements	This area comprises the use of alternative fuels such as ethanol to reduce emissions. Major obstacles are higher cost of production and lower energy densities.
Road Enhancements	The expansion and maintenance of transport infrastructure can reduce fuel consumption, but it has the side effect that it can also increase traffic due to increased accessibility.
Hybrid Vehicles	Hybrid trucks are currently being employed in city services (e.g. delivery trucks, garbage trucks, etc) use up to 25% less fuel.
Multimodal Transportation	Refers to the combination of multiple modes of transport, particularly road with rail or ship. However, infrastructure improvements need to be made to increase its appeal to the general transport market.

External Initiatives	
Consolidation	This initiative refers to increasing the load factor of vehicles to decrease the number of shipments and hence, total fuel consumption. Inter-company coordination could improve its effectiveness.
Return Loading	Focuses on trying to make empty lorries have some cargo when repositioning.
Route Planning	Can, according to some authors, substantially decrease the number of ton/km with the use of information technology and GPS systems to improve efficiency.
Ordering Systems	Studies the effects that ordering systems such as Just in Time have on the environment and these studies can be taken into account when restructuring logistic systems.
Packaging	By using efficient packaging methods and materials, the total weight and volume of the goods can be decreased and load factors could therefore be increased.
Driving Behavior	Eco-driving techniques and general driver education are also ways to decrease fuel consumption and emissions.
Mobile Communication	A change in route planning can be communicated quickly and avoid unnecessary driving (Fredholm 2006).
Positioning Systems	GPS avoids the loss of control over where vehicles are located by traffic management can lead to cost savings of up to 20% (Fredholm 2006).
Traffic Information	Includes information on road situations, road maintenance, eventualities, accidents, weather problems, etc. With such a system, drivers can simply be redirected to a new and better route. (Fredholm 2006).

Appendix 5 – On the Road to Climate Neutral Transportation: Project Partner Commitments

Chalmers

- Ensure that all our students reflect on sustainable development and the role of transportation in this development during their studies at Chalmers
- Develop effective cross-disciplinary research environments and initiate new research projects aiming to reduce the climate impacts from transportation
- Organize cross-sector workshops to initiate knowledge exchange between various agents in order to promote further engagement and partnering in this area

PREEM

- We will transition our pure oil refineries toward bio-refineries. By 2011, we aim to have substituted biomass for 10% of the crude oil used to produce Swedish diesel
- We will increase the amount of renewable fuels in low blend gasoline and diesel from 5% to 10%
- We will work toward the most efficient production and use of transportation fuel, be it fossil-based fuel or not
- We will continue to develop energy-saving products and services

Schenker

- Provide training in eco-driving for all vehicle operators
- Phase out all older vehicles with Euro0/1/2 engines
- Power our vehicles with the most environmentally friendly diesel available

Volvo Trucks

- Top priority: improved fuel efficiency
- Volvo Trucks will lead the way by steadily improving fuel efficiency of Volvo trucks by at least 1% each year
- We will stay in the lead on hybrid technology for heavy trucks
- We will actively work on the transition to renewable fuels and will assume a leadership role in the development of related vehicle technology
- We will work towards novel shipping solutions that contribute to increased shipping efficiency and reduced carbon dioxide emissions

Swedish Road Administration

- Implement eco-driving requirements for all driver’s licenses
- Support development of new transportation solutions that make it possible to leverage the road network for longer and heavier vehicles
- Support the development of innovative solutions for deliveries in urban settings

VLC Annual Carrier Survey

Purpose

The purpose of the Carrier Survey is to collect data for:

Follow up on internal environmental & safety objectives
Follow up on environmental, safety & quality requirements for carriers
Performing environmental calculations

Scope/Limitations

All major contracted carriers are requested to complete the annual survey.

Description

Invitation

Carriers are issued the annual survey via the World Wide Web. The purchasing department establishes the list of carriers invited to participate in the survey.

Survey Questions

Survey questions can vary from year to year, but for follow-up on environmental, quality & safety objectives and requirements, the following questions must be included:

- Carrier emissions of CO2, NOx, SOx and PM in g/tonkm (or equivalent), or information that enables VLC to calculate these emissions
- Request for copy of ISO 9001 (or equivalent) certificate
- Request for copy of ISO 14001 (or equivalent) certificate
- Sulphur content in bunker fuel for sea carriers
- Euro-class for truck fleets for road carriers
- Questions about road safety: drugs and alcohol, speed, use of safety belt, loading security, driving and resting times.

Results

The Carrier survey provides VLC management with the following results

- Percentage of carriers with ISO 14001 (or equivalent) certificate
- Percentage of carriers with ISO 9001 (or equivalent) certificate
- Average US/Euro-classes for all road transports
- Average sulphur content in bunker fuel for sea transports
- Emission factors for all carriers
- Average emission factors per transport mode
- Percentage of drivers with fuel efficient driver-training
- Percentage of carriers with policies for the different road safety issues
- Percentage of carriers with methods to follow up road safety

Internal communication

These results are communicated internally to:

1. Purchasing departments & Purchasing Board
2. First and second level management review
3. Update the Attention & Observation lists for carriers who fail to meet performance requirements

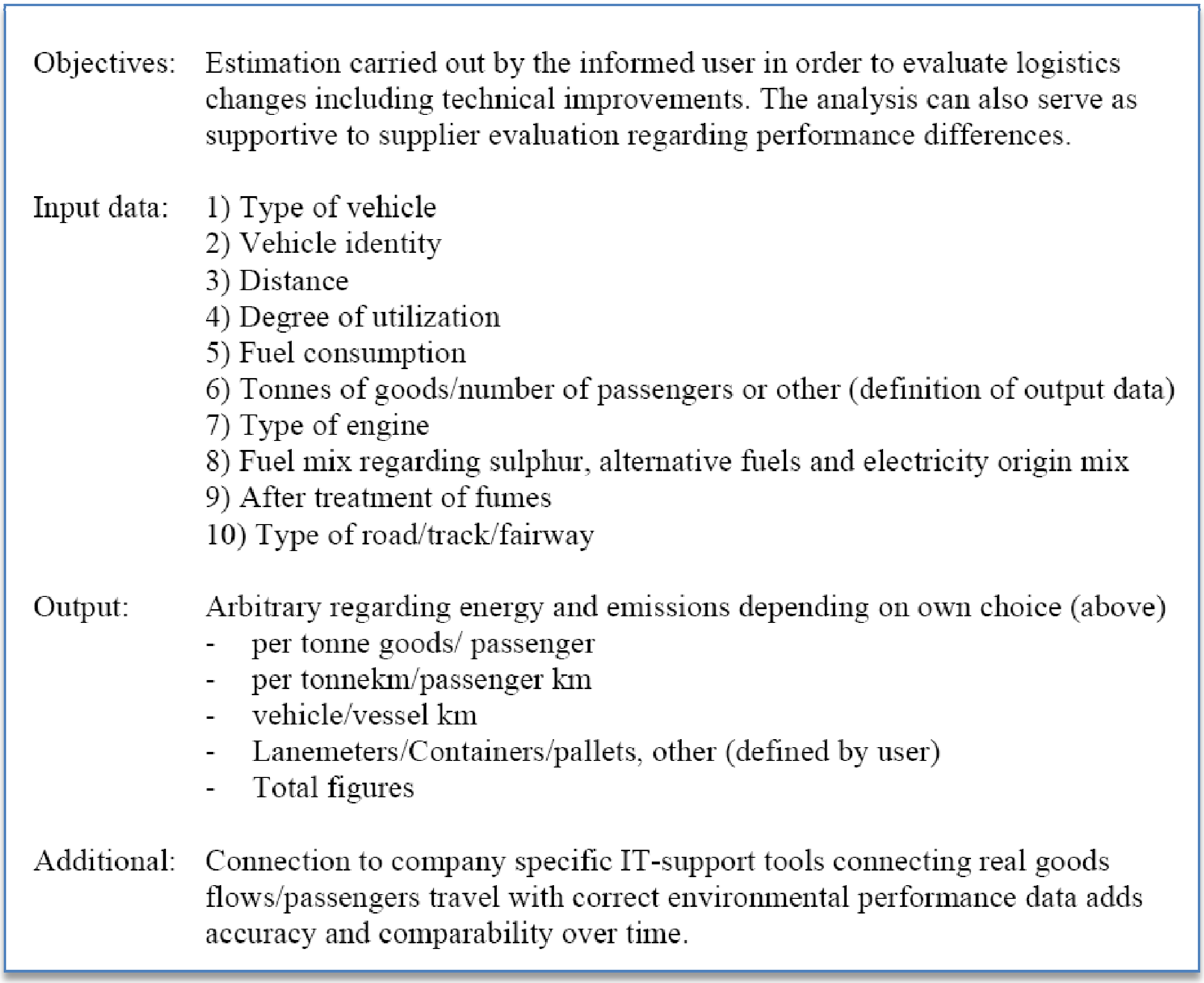
Feedback to carriers

Feedback to carriers shall be sent out after each carrier survey. The feedback shall consist of a document containing the most important information derived from the survey.

Responsibility

The VLC Environmental Manager is responsible for carrying out the survey, and for validation, compilation and storing of the quality, safety and environmental results. The Environmental Manager is responsible for distributing and communicating the results internally and for providing feedback to the carriers.

Appendix 7 – NTM (2007) Accuracy Level 3



Objectives: Estimation carried out by the informed user in order to evaluate logistics changes including technical improvements. The analysis can also serve as supportive to supplier evaluation regarding performance differences.

Input data:
1) Type of vehicle
2) Vehicle identity
3) Distance
4) Degree of utilization
5) Fuel consumption
6) Tonnes of goods/number of passengers or other (definition of output data)
7) Type of engine
8) Fuel mix regarding sulphur, alternative fuels and electricity origin mix
9) After treatment of fumes
10) Type of road/track/fairway

Output: Arbitrary regarding energy and emissions depending on own choice (above)

- per tonne goods/ passenger
- per tonnekm/passenger km
- vehicle/vessel km
- Lanemeters/Containers/pallets, other (defined by user)
- Total figures

Additional: Connection to company specific IT-support tools connecting real goods flows/passengers travel with correct environmental performance data adds accuracy and comparability over time.

Appendix 8 – Emissions Accounting Report

Belgium and France via Prague to Sweden VOLVO

Customer Total

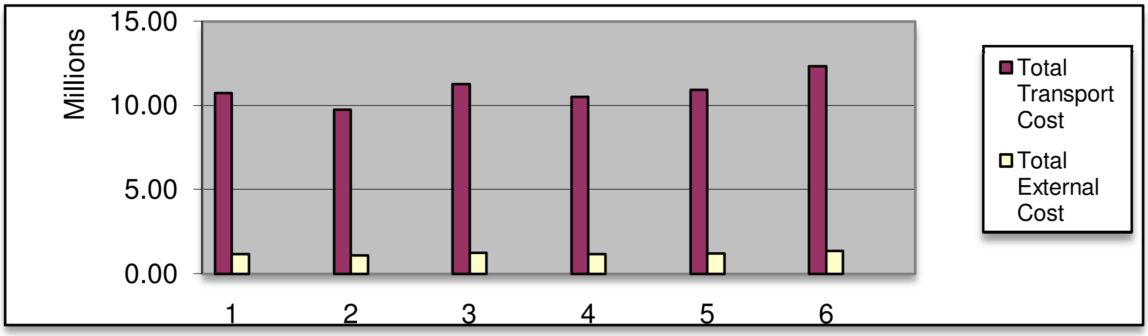
Destination Factory Total

Emissions Costs Source NTM

Units Produced

3000

Set-up/Period	Total Transport Work (tkm)	Total CO2 (kg)	Total NOx (kg)	Total SOx (kg)	Total PM (kg)	Total Transport Cost (SEK)	Total External Cost (SEK)
1	170,810,427,599.30	10,457,000.00	5,736,674.08	13,871,207.85	187,739.48	10,734,424.16	1,193,787.44
2	155,282,206,908.45	9,506,363.64	5,215,158.26	12,610,188.95	170,672.25	9,758,567.42	1,085,261.31
3	179,350,948,979.26	10,979,850.00	6,023,507.79	14,564,768.24	197,126.45	11,271,145.36	1,253,476.81
4	167,394,219,047.31	10,247,860.00	5,621,940.60	13,593,783.69	183,984.69	10,519,735.67	1,169,911.69
5	174,226,636,151.29	10,666,140.00	5,851,407.57	14,148,632.00	191,494.27	10,949,112.64	1,217,663.19
6	196,431,991,739.19	12,025,550.00	6,597,175.20	15,951,889.02	215,900.40	12,344,587.78	1,372,855.56
Total	1,043,496,430,424.81	63,882,763.64	35,045,863.49	84,740,469.76	1,146,917.52	65,577,573.03	7,292,956.00



	Gr CO2 per unit produced	Gr NOx per unit produced	Gr SOx per unit produced	Gr PM per unit produced
P1	3485.666667	1912.224695	4623.735949	62.57982522
P2	3168.787879	1738.386086	4203.396317	56.8907502
P3	3659.95	2007.835929	4854.922746	65.70881649
P4	3415.953333	1873.980201	4531.26123	61.32822872
P5	3555.38	1950.469188	4716.210668	63.83142173
P6	4008.516667	2199.058399	5317.296341	71.96679901
	21,294 Kg	11,682 Kg	28,247 Kg	382 Kg