

Greening Business Information Systems

A case of Volvo Information Technology

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Abstract

Efficient and effective environmental information processing is a key element for the improvement of an organization's environmental performance. Business Information Systems (BIS) are recognized as a tool for the facilitation of collecting, storing, processing and communicating any kind of information. However, there are other benefits that BIS can provide for a company. These benefits are related to the effective use of information, such as support of informed decision-making, increase of overall environmental awareness in an organization and, as a consequence, behavioral change. Therefore, the purpose of study is related to the extension of BIS' functionalities through the integration of the environmental information flow.

The efficient and effective integration of environmental information flow is pursued by means of application of the multi-disciplinary approach where organizational and cybernetic science and environmental management are combined. Beer's Viable System Model and Organizational Information Processing Theory are the main theories used for the assessment of studied information systems and information technology solutions in the purchasing process. The studied IT solutions are deployed in the areas of supplier evaluation, logistics and business traveling. The Environmental Information System Evaluation Framework (EISEF) is the principal outcome of the research work.

The research implications are two-fold. The scientific implication is based on the application of the aforementioned theories for the environmental information processing by means of Business Information Systems. According to the results of literature review, a similar approach has not been used before in this field. The practical implications are EISEF itself and recommendations for its use that are also the principal outcomes of research.

Executive Summary

The availability of information is the key element for learning, knowledge acquisition and thus awareness of employees, decision-makers and top management in an organization. This notion is valid also for environmental work. Understanding the nature of an organization is a condition for the design of information systems where the environmental information will be used for taking effective measures towards improved environmental performance. That is why it is essential to perform multi-disciplinary research where knowledge about structures of organization and Information Systems is combined with expertise in the environmental field. This combination can support efficient and effective environmental information management.

For instance, costs related to the environmental information management can reach up to 60% of the total costs of environmental activities. One of the strategies to reduce these expenses is to deploy environmental software which is used specifically for the purposes of environmental management, e.g. for information related to environmental impacts, various compliance reports, monitoring etc. However, since Business Information System (BIS) is the main tool for information collection, storage, processing and communication in many enterprises, adding new software applications requires additional efforts for its integration with the main business data flows. In addition to this, the development and maintenance of BIS are costly and time consuming. Therefore, there is the need to reduce costs related to the use of BIS and costs related to the environmental information flow. This would make information systems more efficient. However, it is not sufficient only to handle environmental information, but as stated in the previous paragraph, to provide necessary knowledge which will be used for the environmental performance improvement of an organization. This aspect would make information systems effective. Hence, the question of extension of the functionality of existing Business Information Systems arises, where the environmental performance improvement of an organization is the key aspect.

For this reason, the current research aims to answer the following research questions:

1. How can Business Information Systems help to improve the environmental performance in organizations?
2. How can business information systems and information technology solutions be integrated in an organization to improve the environmental performance in terms of efficiency and effectiveness?

In order to answer the research questions, an extensive literature review was conducted focusing on the relationships between an organization and information technology, an organization and the environment and a combination of these three elements. This formed the Context Framework. The main focus was made on information processing and the challenges related to it in each of these areas. The principal issue in the organizational information processing – the *efficiency and effectiveness* of information handling – is discussed using a number of established theories. These theories were used as a base for the analytical framework to analyze the data obtained from case studies.

The study took place at Volvo Information Technology (Volvo IT) unit of Volvo AB in Gothenburg (Sweden). The research focused on the purchasing process, namely on the stages of supplier evaluation, logistics and business traveling, which are known to represent the activities with major environmental impact. The data about the IT solutions used in these areas were collected through personal interviews with application developers and their direct users. In addition, a survey of the environmental managers and coordinators in Volvo Group was performed to complement the data. This allowed receiving a general understanding about the level of IT support in environmental management processes.

Insight into the company's purchasing process as a case study gave the possibility to systemize the data and to identify similarities with the experience obtained during the literature review. Most of the aspects related to integration of IT and environmental management were confirmed. For instance, the environmental management is poorly supported by the current IT infrastructure; the data about environmental performance is difficult to retrieve, and there is a lack of sufficient knowledge about the environmental issues among Volvo's IT professionals.

To answer the second research question, the collected data about IT support for supplier evaluation, logistics and business traveling was examined using the analytical framework. The applied method allowed identifying the problems related to environmental information processing and practical recommendations for the improvement of information systems were given. These recommendations concerned not only technical possibilities for the environmental information flow assurance, but also about overall organizational aspects such as performance indicators, policies or targets.

The Environmental Information System Evaluation Framework (EISEF) was proposed as a tool for further application by any IT provider or IT support department. The main purpose of this tool is to evaluate information systems or information technology solutions from the perspective of integrated environmental data flow and to give guidance for integration of the environmental information into any Business Information System with minimum resources and avoiding information overload. EISEF represent the summarized experience obtained from practical and theoretical knowledge. It includes four steps: process selection, information system and information technology (IS/IT) solution selection IS/IT solution evaluation and the criteria for final IS/IT solution. The criteria are selected in a way that the final IT solution should be able to provide reliable and up-to-date information about the environmental impacts from the process to all relevant users involved in the process, as well as it can be available for the interested stakeholders.

There are several contributions of this research with several practical implications. First, the Cybernetic Theories were tested during the assessment of information systems from the viewpoint of effective handling of environmental data, while the Organizational Information Processing theory has been used for the development of specific criteria for all steps of the evaluation framework. According to the conducted literature review, no similar approach has been used before with the same purpose. Secondly, since the issue of environmental sustainability of IS is still in its infancy, a practical approach for integration of environmental management issues into organizational IS is proposed. It is equally valuable for IT providers and for business organizations. The main identified benefits for the business are:

- reduced costs for environmental information management;
- better decision-making based on reliable and high quality data;
- involvement of a large number of employees that results in increased environmental awareness and behavioral change.

The integration of environmental perspective into products and services provided by an IT company would not only add value to these outputs, but would also increase customers' satisfaction and help pursuing a more sustainable development of the business. However, it would be beneficial if this method is tested for other information systems and IT solutions.

Table of Contents

List of Figures

List of Tables

1	INTRODUCTION.....	1
1.1	BACKGROUND AND PROBLEM DEFINITION	1
1.2	PURPOSE AND RESEARCH QUESTIONS.....	2
1.3	SCOPE AND LIMITATIONS.....	3
1.4	METHODOLOGY.....	4
1.4.1	<i>Phase 1: Context</i>	5
1.4.2	<i>Phase 2: Case study research and main data collection</i>	6
1.4.3	<i>Phase 3: Analysis and interpretation of data</i>	7
1.5	THESIS OUTLINE.....	8
2	ENVIRONMENTAL INFORMATION MANAGEMENT AND ITS IT SUPPORT IN THE ORGANIZATION: LESSONS LEARNT	9
2.1	ORGANIZATION AND IS/IT: DOES IT REALLY MATTER?.....	9
2.1.1	<i>Business Information System</i>	9
2.1.2	<i>Enterprise Resource Planning</i>	11
2.2	ROLE OF ENVIRONMENTAL INFORMATION FOR ORGANIZATION.....	12
2.2.1	<i>Environmental Management Accounting in the business</i>	13
2.2.2	<i>Performance measures</i>	14
2.2.3	<i>Reporting</i>	15
2.3	THE STRATEGIES FOR INTEGRATION OF ENVIRONMENTAL INFORMATION FLOW IN AN ORGANIZATION BY MEANS OF INFORMATION TECHNOLOGY	16
2.3.1	<i>Environmental Software and its use in an organization</i>	17
2.3.2	<i>Environmental Management Information Systems</i>	20
2.3.3	<i>Data Warehousing</i>	21
2.4	CONCLUSIONS DERIVED FROM LITERATURE REVIEW	22
3	INFORMATION PROCESSING IN ORGANIZATION – A REVIEW OF THEORIES.....	26
3.1	CYBERNETICS THEORIES.....	26
3.1.1	<i>Ashby’s Law of requisite variety</i>	26
3.1.2	<i>Beer’s Viable System Model</i>	27
3.2	ORGANIZATIONAL INFORMATION PROCESSING THEORY	28
3.3	RELEVANCE OF THE THEORIES FOR THE CURRENT RESEARCH	29
3.4	ANALYTICAL FRAMEWORK FOR THE ANALYSIS OF THE COLLECTED DATA.....	32
4	PRESENTATION OF VOLVO INFORMATION TECHNOLOGY	33
4.1	THE IT SUPPORT OF THE ORGANIZATION: VOLVO IT “LET’S MAKE SURE”.....	33
4.2	ENVIRONMENTAL AWARENESS OF THE IT PROVIDER: WHERE VOLVO IT STANDS?	35
4.3	INTEGRATION OF THE IT INFRASTRUCTURE FOR ENVIRONMENTAL CARE: WHAT VOLVO IT DOES ABOUT IT?	36
5	SUPPORT OF THE ENVIRONMENTAL WORK IN THE PURCHASING PROCESS BY IS/IT SOLUTIONS	38
5.1	PURCHASING IN VOLVO GROUP AS THE FOCUS AREA	38
5.2	INFORMATION SYSTEM THAT SUPPORTS PURCHASING IN VOLVO GROUP.....	38
5.3	PURCHASING IN VOLVO GROUP AND ENVIRONMENT.....	39
5.3.1	<i>Environmental aspects in the Purchasing: mapping focus areas</i>	40
5.4	DOES EXISTING INFORMATION SYSTEM HELP TO MANAGE ENVIRONMENTAL ASPECTS?.....	42
5.4.1	<i>Supplier evaluation</i>	42
5.4.2	<i>Logistics</i>	43
5.4.3	<i>Business traveling</i>	45

6	INTEGRATING ENVIRONMENTAL INFORMATION IN THE BUSINESS INFORMATION SYSTEM.....	47
6.1	VIABILITY OF THE IT SOLUTIONS AS THE INFORMATION SYSTEMS.....	47
6.1.1	<i>Operations (S1) and Coordination (S2).....</i>	47
6.1.2	<i>Control (S3) and Auditing (S3*).....</i>	48
6.1.3	<i>Intelligence (S4) and Policy (S5).....</i>	49
6.1.4	<i>Viability.....</i>	50
6.1.5	<i>Internal Model and Double-loop learning.....</i>	50
6.1.6	<i>Requisite variety.....</i>	50
6.1.7	<i>Recursion.....</i>	51
6.2	POSSIBLE IMPROVEMENTS DERIVED FROM THE ANALYSIS PART.....	53
6.2.1	<i>Supplier evaluation.....</i>	53
6.2.2	<i>Logistics.....</i>	54
6.2.3	<i>Business traveling.....</i>	54
6.3	ENVIRONMENTAL INFORMATION SYSTEM EVALUATION FRAMEWORK (EISEF).....	56
6.3.1	<i>Process selection.....</i>	58
6.3.2	<i>IS/IT solution selection.....</i>	59
6.3.3	<i>Existing IS/IT solution evaluation.....</i>	60
6.3.4	<i>Final IS/IT solution criteria.....</i>	61
6.4	PRACTICAL SUGGESTIONS FOR THE APPLICATION OF THE ENVIRONMENTAL INFORMATION SYSTEM EVALUATION FRAMEWORK (EISEF).....	62
7	CONCLUSIONS AND RECOMMENDATIONS.....	65
7.1	ANSWERS ON THE RESEARCH QUESTIONS.....	65
7.2	WHAT ELSE CAN VOLVO IT DO TO BE A DRIVING FORCE?.....	66
7.3	GENERAL IMPLICATIONS FOR IT PROVIDERS.....	67
7.4	CONTRIBUTION AND FUTURE RESEARCH NEEDS.....	68
	BIBLIOGRAPHY.....	70
	ABBREVIATIONS.....	74
	DEFINITIONS.....	75
	APPENDIX I.....	76
	APPENDIX II.....	78
	APPENDIX III.....	79
	APPENDIX IV.....	80
	APPENDIX V.....	81
	APPENDIX VI.....	82

List of Figures

Figure 1-1 The Context Framework for the conducting literature review and analysis of the company.	5
Figure 1-2 The principal cycle of the conducted interviews during Phase 2	7
Figure 1-3 Thesis outline	8
Figure 2-1 Interactions of information system and organization. Adopted from (Coakes & Elliman, 1999)	11
Figure 2-2 Systematic collection of eco-efficiency information.....	15
Figure 2-3 Architecture of a data warehouse.....	22
Figure 3-1 Information and uncertainties in the system	31
Figure 3-2 The measurement of Sustainable Performance of the IT solution. Adopted from Lewis & Stewart (2003)	31
Figure 3-3 Viable System Model as the analytical framework.....	32
Figure 4-1 Volvo Group Structure.....	33
Figure 4-2 Volvo IT is moving towards Global solutions.....	34
Figure 5-1 Volvo Group Purchasing Global and local System.....	39
Figure 5-2 Framework for the assessment of the purchasing process.....	41
Figure 5-3 EnvCalc.....	44
Figure 6-1 Business travel system in Volvo Group	55
Figure 6-2 Environmental Information System Evaluation Framework (EISEF)	57
Figure 6-3 Process selection plot.....	63
Figure 7-1 IT solution and conditions for the sustainable growth of an IT provider	68

List of Tables

Table 2-1 Categories of Environmental Software18

Table 6-1 The summary table of the analysis of IS/IT solutions according to the Viable System Model.....52

1 Introduction

This section provides the introduction to the research work. A brief background of the study and argumentation of the research problem are presented. In addition to this, principal research questions, as well as scope and limitations of the work are provided. This section will help also to grasp the research methodology and justification of selected data collection approaches. Section 1.5 provides the thesis outline which aims to facilitate the reading and understanding of collected information flow and research approach as such. Definitions of the terms used in this paper are given at the end of the document.

1.1 Background and problem definition

The emphasis on environmental performance of successful companies is no longer driven only by the legal compliance, but also by business opportunities. The environmental care is used for many purposes such as improved image, attraction of the investors and customers, better efficiency of the processes or even innovation and creating new markets or new business models. Companies are gaining competitive advantage on the market “looking” at the Environment (Esty & Winston, 2006; Harvard Business School Press, 2007; Willard, 2002). The level of environmental awareness among employees determines the success of any actions towards the improvement of organizational environmental performance. The main components of corporate environmental awareness are environmental knowledge, environmental values, environmental attitudes and revealed willingness to act, where knowledge is the basis for shaping individuals’ thinking, values, attitudes and indirectly their behavior (Nemcsicsne, 2008). In order to acquire the necessary knowledge for organizational learning, the information should be retrieved and stored, forming *organizational memory*, then, information should be *interpreted and distributed*. After all, various types of *learning*, for example through observing the experience of other organizations or using information about own environmental performance, form the environmental knowledge (Huber, 1991). Basically, the knowledge is formed by contextualization of the information flow (Nonaka, 1994).

The main instrument for the information handling within an organization is the Information System (IS). That is an integrated set of the components for collecting, storing, processing and communicating information (Encyclopedia Britannica, 2008). Since the primary focus is on the improvement of environmental performance of a business organization, then Business Information System (BIS), as “a set of the business practices, procedures and processes that are implemented by computer application programmes”¹, would represent the major interest for the further discussion. In fact, it has been recognized in the environmental management field that, *the integration of information technologies in the organization is a way to bring the environmental initiatives to the core business and a way to make them happen in the most cost efficient manner* (Esty, 2007; Intellect, 2008; Moore, 2002; Molloy, 2007).

Apparently, the following drivers for the deployment of information technologies (IT) for environmental management have been identified (Rikhardsson, 2001):

1. higher integration of corporate environmental management with business management operations, thus respective information flows;

¹ This definition for BIS is used in the thesis, however the source of it is not defined clearly even though it can be found in the following document www.imc.org/ietf-ediiint/old-archive/doc00000.doc

2. increased regulation and market driven voluntary initiatives impose higher costs of the management, hence there is need to reduce them by means of the effective information management;
3. companies require more detail and advance monitoring of the activities in order to improve their performance

Despite of these drivers for use of IT for the efficient and effective environmental information management, the deployment of IT infrastructure for this purpose is still rather low. According to the study conducted by PriceWaterhouse Coopers (Hutter, 2001), there are issues related to the utilization of business IT infrastructure for environmental management such as low integration of environment in business processes; environment, health and safety areas are not integrated in existing IT system; little use of standardized software; companies see challenges in the operational tasks but not new trends with use of the technologies, like e-business for example. Besides this, it has been recognized that environmental information flow² in the business system is rarely supported by IT planning. The main reasons are the complexity of environmental matter and lack of the awareness among IT professionals (Molloy, 2007). Hence, the following question appears: **How can environmental information flow be integrated into Business Information System in such a way that environmental performance will be improved?**

Considering the preliminary literature review in the fields of the organizational studies, information systems and environmental management, the lack of the research in the area of evaluation of IS from the environmental information management perspective has been determined. However, the need for sustainability thinking in IT infrastructure has been emphasized recently (Standing & Jackson, 2007) as well as attempts to evaluate the environmental impact of IS (Haigh & Griffiths, 2008). Most of the relevant studies are related to the problems and recommendations for integration of a variety of environmental software in BIS or indicate the sources of the environment related information in existing IS, like Enterprise Resource Planning software. In addition to this, these research works are based on the empirical experience in the companies without theoretical approach to the problem, as compared with organizational studies or information processing in the business where various scientific theories are widely applied. Though, the scientific approach can help not only to look at the situation in a systematic way and to identify the sources of problems but also to assist in providing more general framework for the assessment which can be used in other circumstances in comparison with the studied company. Therefore, current thesis aims to cover these research gaps through the application of the scientific theories in order to solve the problem of efficient and effective environmental information management in the existing Business Information Systems.

1.2 Purpose and research questions

The principal purpose of this thesis is *to contribute to the understanding of how Business Information Systems can help to reduce environmental impacts of the organization*. The second purpose of the research work is *to provide guidelines for the support of IT providers and organizations* for the integration of Information Systems (IS) and Information Technology (IT) solutions³ in a way

² For examples of environmental information flows in an organization see Appendix II

³ Further in the text will be used as "IS/IT solution". This term has been chosen to refer to the combination of the information system and IT solution, since these subjects are different in their nature, but aim to provide a similar function, i.e. information handling for the business purposes. Its separate accepted definitions can be found in the "Definitions" section at the end of the document.

that these solutions will enable the improvement of environmental performance of the organization.

In order to achieve the purpose, the following two research questions have been selected:

- How can Business Information Systems help to improve the environmental performance in organizations?
- How can business Information Systems and Information Technology solutions be integrated in an organization to improve the environmental performance in terms of efficiency and effectiveness?

1.3 Scope and limitations

The scope of the research is limited to the studied company which provides also the basis for the case studies. During this research, application of the IT solutions in the manufacturing industry (business units of the Volvo Group) as well as in the service sector (Volvo IT and Volvo Logistics) have been reviewed. Since the company is Global, main focus has been made on the local, Sweden, application of the IT solutions. However, the Swedish part of the company represents the major share of all operations. Hence the results can be considered as representative and have high potential of replication in other geographical areas of Volvo Group, as well as any IT provider.

The selected research focus defines the scope and limitations of the thesis. The **process of purchasing** has been chosen as the mainframe for the studied solutions, due to this area's significance for the overall environmental performance of the organizations and also because of the complexity related to the accounting of environmental impacts. The selected focus areas: **supplier valuation, logistics and business traveling** represent the areas of biggest environmental impact related to the purchasing process. Therefore, existing IS/IT solutions will be studied in relation to the application in these three focus areas. Use of the same research approach for the different types of environmental aspects in each of the focus areas and various IS/IT solutions would assist in the development of the evaluation framework which would be suitable for other IS/IT solutions in other processes.

The scope of application of IS/IT solutions is limited to the environmental information handling, i.e. the information that is related to the management of environmental aspects of the purchasing process. However, not all aspects are included but only those identified by the company as significant or to be considered in the nearest future:

- supplier evaluation is characterized by the environmental performance of the suppliers which is measured as existence of the certified environmental management system (EMS) according to the ISO 14001 standard and by the general environmental evaluation according to the established Volvo Group criteria;
- even though the environmental impact from logistics is not measured on a regular basis but only the for the decision-making when new logistics proposal are prepared, the IS or set of the IT solutions will be evaluated from the perspective of potential ability to generate the information about impact, i.e. CO₂e; and
- concerning travel plan and expenses solution, the sought environmental information will be related to the accounting of the business travel related emissions in CO₂e.

1.4 Methodology

Qualitative exploratory case study research method is accepted as the most suitable for the understanding of interactions between information technologies and organizational context (Darke et al., 1998). Volvo Information Technology has been selected as a case study company because of its extensive experience in the deployment of the various information systems in Volvo Group, a large auto manufacturer with more than 100 000 employees around the World. The close connection to the main customer, Volvo Group, allowed exploring the implemented IS/IT solutions from users' perspective, i.e. their needs and experience in work with IT applications and managing environmental impacts. In addition to this, working on-site in their headquarters during three months has helped to obtain an understanding of the deployment process of IT projects. Consultations with developers on the subject of feasibility of the proposed changes in the IS/IT solutions also been completed.

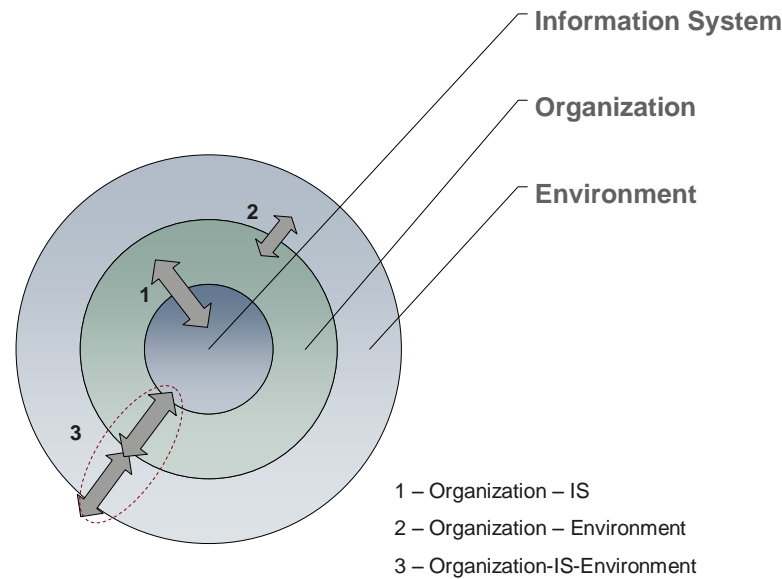
The research focus with 3 focus areas has been selected in order to identify the similar causal aspects within each case which produce certain expected positive outcomes, i.e. reduction of the impact on the environment. This approach allows integrating and scaling up the data provided by each of the cases. Data collection is based mainly on the collection of primary data from the studied organization. Data is retrieved from the intranet, company's materials, interviews and survey. List of the interviewed people is in Appendix I of the thesis. The interviews are personal semi-structured interviews of about 45-60 minutes.

In order to provide the theoretical and practical context, the data collection has been based on the Context Framework, depicted in the Figure 1-1, where Information System is in the core of the Organization and supports main processes, while the Organization operates in the Environment and has the environmental impact consequently. Looking at this figure, it can be stated that in order to find the connection between IS and environment, there is need to "pass through" the organization layer, i.e. to consider the organization's parameters and structure. This concept underlines the main principles of the research, i.e. multidisciplinary approach to the problem.

Therefore, the study is based on the research of various interactions between organization and IS/IT infrastructure, organization and environment, and interaction among all these three components. The framework helped to scope the data collection and to structure it, building the necessary knowledge in this field. Moreover, the similar structure has been used also in the study of the environmental sustainability evaluation of the information systems done by Haigh & Griffiths (2008). As a result, the literature review has three main sections where existing literature has been reviewed in a way that would give an overview of these three main types of relations. The context of the case study company, including the description of research focus "Purchasing process", is explored in the same way. Therefore Phase 1 and Phase 2 of the research follow this structure. Application of the identical structure to the research phases related to the context allowed collection of relevant information. This assisted in the comparison of the experience from the literature review and real practice in the case study company. Together with the case study research, where the specific aspects of integration are explored, the approach described above provides the possibility to triangulate and support all findings.

The phases of research are described in the further sections, where Section 1.5 provides the thesis outline in the graphical form.

Figure 1-1 The Context Framework for the conducting literature review and analysis of the company.



1.4.1 Phase 1: Context

This phase can be split in three major parts:

1. The main purpose of this part is to identify the possible ways in which BIS can be used to improve environmental performance of the organization and to reveal existing knowledge in the area of application of Information Systems for the efficient and effective management of environmental information. The literature review has been conducted in accordance to the Context Framework described in the previous section. In addition to the basis for answer on the first research question, the research gaps in the studied field have been identified. The obtained knowledge is applied to review the case study company, where the main findings and conclusions from literature review were examined, and some of them are confirmed.
2. Since main emphasis is made on the environmental information management in the organization, an overview of theories related to the information processing has been conducted. This part also includes the argumentation for the applicability of these theories. The major attention has been paid to the understanding of relationships between an organization, information and ability to handle the surrounding environment. Basically, the solution for the identified in literature review challenges has been sought. The analytical framework for the collected empirical data about IS/IT solutions is derived from the results of theoretical context. The preliminary findings are also used for the IS/IT evaluation process, as well as included in the evaluation framework.
3. This part of the context aims to provide an understanding of the organizational and IS structure in the case study company. The scoping of the research field and identification of the areas for the IS/IT solutions evaluation are also a part of the organizational context, i.e. where the most significant environmental aspects of the purchasing process are detected. The necessity of this stage is induced by the size of the company and amount of the provided IT solutions. This selection is based on the interviews with key persons from different Global Processes of Volvo Group, as well

as personnel from the department “Process and Quality” of Volvo IT. However, only the presentation of Volvo IT, the situation with environmental work and the relation with Volvo Group in term of IT support of environmental management are described in the thesis. It gives a general knowledge of the Volvo IT as such, the level of the awareness and skills concerning environmental issues and the level of integration of BIS with environmental information flow. The latter aspect has been explored by means of a survey among environmental managers and coordinators in Volvo Group. Even though the scope of the research is limited to Swedish conditions, managers from other Global sites took participation too. This part has helped to provide an insight to the level of environmental awareness in the company as well as how much existing IT solutions are used to collect relevant environmental information. Even though the number of responses is not very high, the response rate was around 55% and interviewees were from the specific target group. The participants are mainly from sites in Sweden and USA and represent automotive manufacturing and non-automotive services. The questions and aggregated data can be found in the Appendix VI. Certainly, this approach can show the situation on the surface only, and does not include assessment of the environmental awareness inside the core processes. Therefore, Phase 2 concentrates more on the specific process and Information Systems used there. The description of Phase 1 is also based on the framework described above (Figure 1-1).

1.4.2 Phase 2: Case study research and main data collection

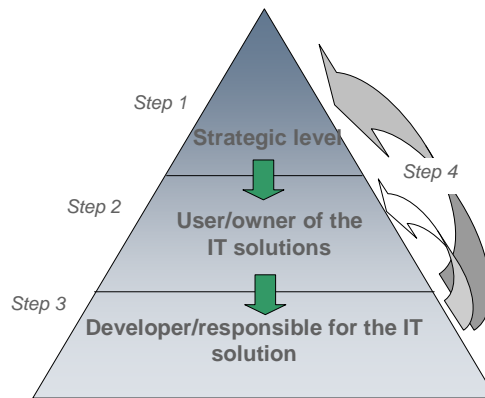
During Phase 2, the researcher pursued the target to identify the key existing IT solutions in each of the focus areas within selected process (supplier evaluation, logistics, business traveling) where the environmental application is possible, i.e. how we can use these IS/IT solutions and separate applications in order to improve environmental performance of the user and the company as such. The general purpose of this phase is to collect necessary information for the further analysis. Data is collected by means of the semi-structured personal interviews with representatives from each area of selected environmental aspects of the purchasing process. Phase 2 has been performed in parallel with Phase 1. The basic steps and argumentation for certain choices for interviewees’ selection are described below and depicted in Figure 1-2. In order to obtain an understanding of the IT support of the supplier evaluation, logistics and business traveling, the answers of the following questions have been sought:

1. What are existing policies or objectives in relation to the environmental impacts?
2. What are main IT applications used in the focus areas and what is their purpose?
3. What kind (format) of data is handled? (define data sources and flows in the selected process)
4. How big is the scope of IT application? (who does it use, how many users, information flow)
5. Where and how is the environmental information processing possible?

All interviews during Phase 2 were performed in the certain stages (Figure 1-2). On the **strategic level**, Global Function Managers of each of the global processes (“Product Development”, “Order to Delivery”, “Delivery to Repurchase” and “Sales to Order”) from Volvo IT side were interviewed. This step is necessary to comprehend the range of the

available IT solutions in the focus areas as well as to identify future interviewees from the following steps.

Figure 1-2 The principal cycle of the conducted interviews during Phase 2



Second step, interviews with user/owner of the IT solutions, has been done with the aim to familiarize with focus area itself. In other words, users were asked about the processes in the focus area and consideration of the environmental aspects there; how do they use IT solutions; what kind of data is retrieved and how the process is measured (key performance indicators). It assisted in the identification of the need for specific data concerning environmental performance. Other outcome of the step is that necessary changes for the improvement of environmental information flow in the area were identified. To assure the quality of the information and accuracy of the statements not only a number of people from the same Business Area (BA) and Business Unit (BU) (BA/BU) have been interviewed, but also from other BA/BU where similar processes and solutions are used.

Third step represents the interviews with developers of the solution and staff responsible for maintenance. This stage has been performed to discuss the feasibility of changes identified on the step 2, considering the scope of application. The main aspects for discussion were: integration in the existing IT infrastructure without major capital investments and use existing data flows to make desired improvements.

Forth step varies in dependence on the situation in the focus area. Basically, after the third step there is a need to come back on one of the previous stages to discuss the identified possibilities further. Its necessary since all IT solutions are developed/changed as a consequence of the customer's needs. This process is a distinguishing feature of the studied company. It implies that the important prerequisite of any solution's improvement is the request from the customer. However, this step is more important for the practical implementation of the desirable modifications and helps to understand the inter-organizational interactions.

1.4.3 Phase 3: Analysis and interpretation of data

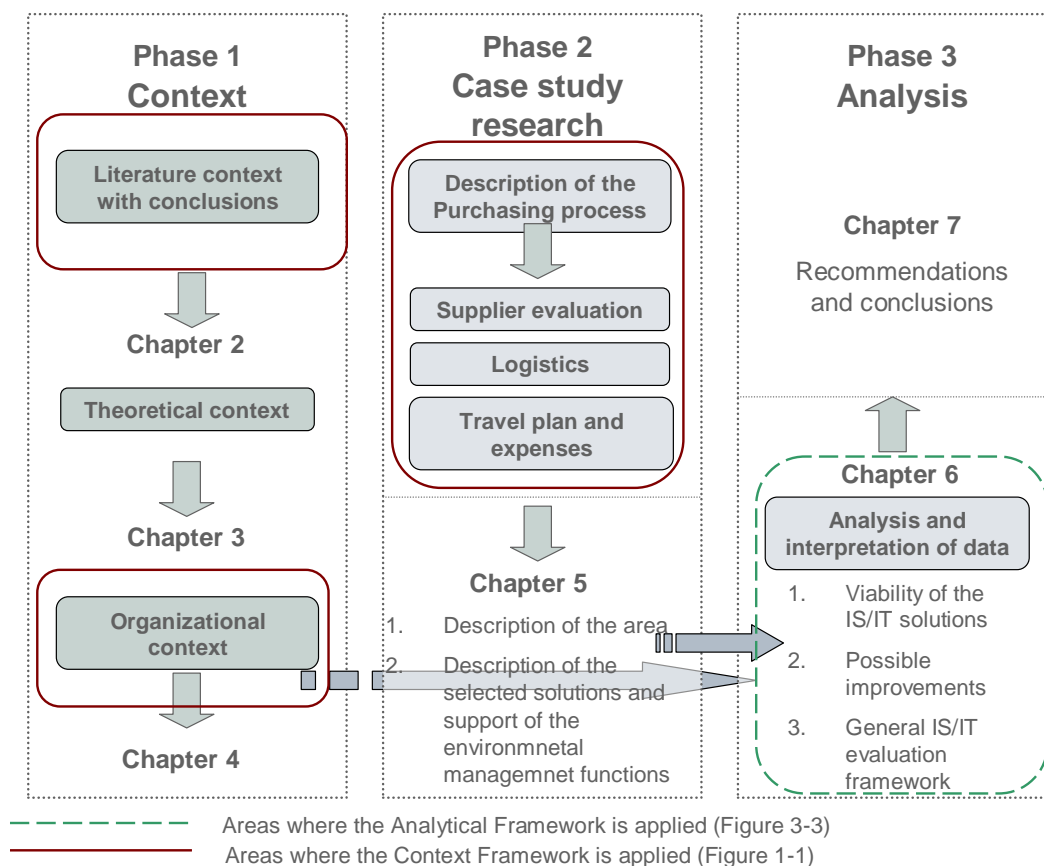
The collected information from Phase 2 has been analyzed in accordance with the analytical framework based on Beer's Viable System Model during Phase 3. The basic purpose is to identify main deficiencies of the existing IS in relation to the support of the environmental information management. This stage assists in giving clear recommendations on how to integrate an IS in the organization to improve environmental performance. However, the principal part of the current phase is to develop a framework which would be applicable to the

selection and evaluation of business IS/IT solutions which have the potential to provide environmental benefits for the company. Therefore, according to the research framework in IT discussed by March & Smith (1995), current research represents the design science where the prescription for improvements will be given following hypotheses deduced from the theories. As a result, the developed model provides the road map for the goal-oriented activities necessary for the improvements. Recommendations and conclusions are a part of Phase 3 too. It covers the overview of the answers on the research questions, recommendations for Volvo IT, for the IT society as such and the possible implementation of further research in this field.

1.5 Thesis outline

The above phases of the research with specific sections and related thesis Chapters are depicted by Figure 1-3. The thesis outline gives the general picture of the research process with main flows of the data. The areas where the Context Framework and the Analytical Framework applied are indicated on the picture. Supplementary information, definitions and abbreviations are presented at the end of the document in the *Appendixes*.

Figure 1-3 Thesis outline



2 Environmental Information Management and its IT Support in the Organization: lessons learnt

This part is meant to uncover the background of interactions between organization, IT and environment. It gives an overview of some studies in the fields where interactions between these three components of the System are explored. The importance of the integration of organizational, IT and environmental infrastructure is emphasized in this chapter. Basically, it is an attempt to answer on the first research question: "How can Business Information System help to improve the environmental performance of organizations?" and to identify the challenges that are recognized by researchers and other experts in the field.

2.1 Organization and IS/IT: does IT really matter?

Certainly it is impossible to cover so big a question in a small chapter of a Master's Thesis since there are many researchers who are working in this field for almost two decades and trying to understand this type of interaction: organization and IT. Various questions and problems are brought to discussions, where the question "Does IT really matter?" put by Nicholas Carr, Harvard Business Review (HBR) editor-at-large, in his article for HBR in May 2003 (Carr, 2003) stirred and confused IT professionals' and business people's minds. Obviously everyone agrees that IT plays very important role in the modern business and resulted in the emerging of New Economy, but what is the level of this importance now: is it just commodity as electricity or it still is able to provide competitive advantage? Of course it is not the objective of this paper, since there is the whole book written about this issue (Carr, 2004), though this chapter explains the function of information system in an enterprise, its benefits and constraints. The section concentrates on the business information system, because it is an essential part of any modern business, and it has influence not only on the efficiency of the processes but also on the corporate culture and values (P. Rikhardsson & Kraemmergaard, 2006). Enterprise Resource Planning (ERP) system is an example of enterprise information systems which has very wide functionalities, including opportunities for the environmental information flow assurance. ERP is briefly discussed in the section.

The primary aim of this section is to understand how IS/IT can be used to foster the changes within an enterprise and in our case, the main emphasis will be made on the improvement of environmental performance. Other purpose is to learn about the problems and obstacles met during IS implementations. This will help give recommendations for successful Environmental Management Information System (EMIS) integration in an enterprise.

2.1.1 Business Information System

Business Information System (BIS) is "a set of business practices, procedures and processes that are implemented by computer application programs". It consists of the *database*, used to define data structures, *application programmes* for data entry, updating and reporting, and *procedures*, which define the data flow (PCmagazine, 2008). Hence, BIS is a set of software applications connected in a certain way and help organize information flows in various processes of the organization. Certainly, talking about "greening" BIS we should not forget that any IS operates on the base of hardware, it uses energy and other resources. However, current paper is targeting only software part of an IS, thus the main interest will be on the topic how BIS is designed from the structural perspective and what is its purpose.

The deployment of BIS can be split on two waves. During the first wave biggest capital investments are done, and it includes also the configuration and implementation. The second

wave is characterized by continuous improvement and maximization of the benefits which could be obtained. Rikhardsson & Kraemmergaard (2006) state that exploring the second wave has significant relevance for academia as well as for business. It is related to the fact that the question of alignment and implementation of BIS is studied to a great extent. Moreover; business also passed this stage, and now is considering how it would be possible to use available resources in a more efficient way or in other words *how else BIS could be used*. The review of the research work in this area emphasizes that these systems are able to provide bigger benefits changing the business' performance, but only with the condition that organization is able to integrate the activities across the value chain (ibid).

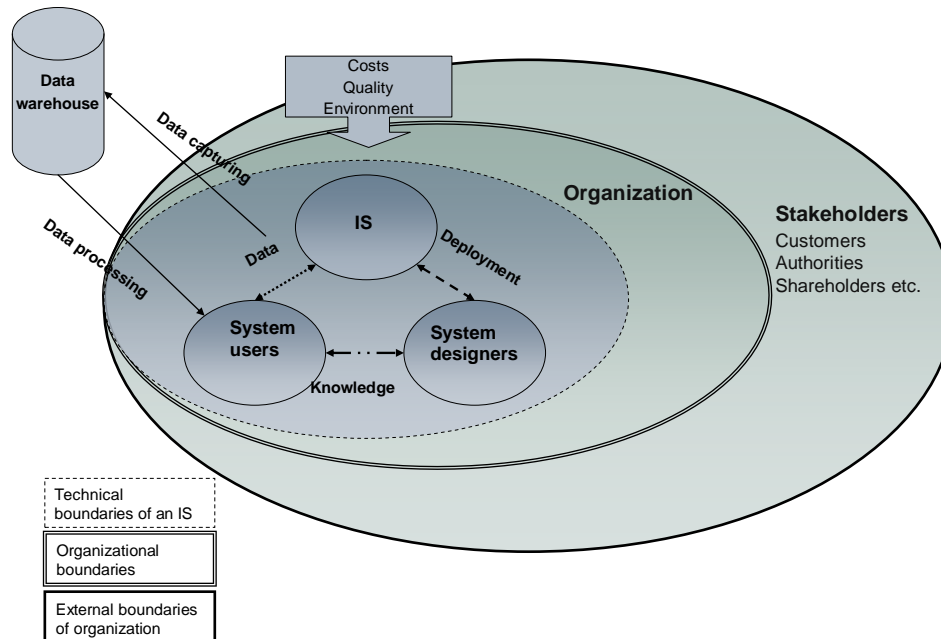
It has been found that BIS has many positive impacts on the organization (ibid). It helps significantly to integrate various processes in one system providing necessary information on various levels. BIS allows the information processing and use to be less centralized. In addition to this, it has positive effect on the employees' awareness and IT literacy due to necessary training activities during implementation phase. All these factors create a common environment and make employees "think beyond their departments" and functions. However, drawbacks have been identified too. In most of the studied cases deployment of BIS required the modernization of processes and how they were conducted. It is induced by the need for a standardization of all processes.

Another interesting finding of this research is that most of the companies made the decision to implement BIS with the hope to gain competitive advantage. But later, they understood that deployment of BIS is rather an "entrance ticket" to the market, a necessary prerequisite for the effective collaboration with customers and suppliers on the global market, since most enterprises implement these systems as well. In a way, this finding proves the opinion stated by Nicholas Carr in his article "Does IT really matter?" (Carr, 2003). According to the interviewees' opinion *BIS can enable the change, but its existence only is not sufficient for change to take place* (Rikhardsson & Kraemmergaard, 2006).

In order to comprehend how BIS should function, it is important to look at the environments that establish the criteria for BIS operation. Coakes & Elliman (1999) propose to widen the perspective from which IS is developed and to take into account various stakeholders. The main viewpoint is made on the System which would be guided not by technical parameters of the processes but more by company's strategy and other stakeholders' push. It supports the opinion stated by Espejo & Watt (1988) that development of the Information Technology and Information Systems as such should be driven towards social design, improving the quality of human life. Taking this into consideration, the boundary setting proposed by Coakes & Elliman (1999) has been adopted in a way which shows also the interaction between "elements" of an IS (see Figure 2-1). The model has been supplemented with an element "data warehouse" or database, as an important component of any IS.

The arrows between elements of the System within technical boundaries stand for the continuous exchange of the information and role of the elements which differs among various connections (Figure 2-1). The knowledge transfer between system designers and system users is one of the crucial aspects. IS should be developed in a way when cognitive and organizational parameters of the system users are taken into account. Another addition to this model is the issues that should be reflected by IS: costs, quality and environmental care. As it has been stated above, it is essential to create IS which would consider different stakeholders' needs, where environmental performance is one crucial part. Especially considering the fact that till the recent times this aspect of BIS has been set aside, and quality and costs were always on the agenda.

Figure 2-1 Interactions of information system and organization. Adopted from (Coakes & Elliman, 1999)



Particular attention has been paid in the research environment to the success factors for implementation of an Information System. Variables that may have influence on the IS deployment are studied. Management's control over scarce resources, user participation and involvement, resource interdependence, environmental uncertainty and risk uncertainty are among them. There are also studies that look at the efficiency and effectiveness of the information processing as a success factor for an IS (Chou et al., 2008). The research shows that high flexibility of the coordination strategy and low goal conflict can lead to more successful software development. The alignment of the theoretical considerations and practical experience in the research of the efficient and effective implementation of IS has been applied also in the study of Gebauer & Lee (2008).

2.1.2 Enterprise Resource Planning

Globalization of the business leads to increased need for the integrated solutions which would be used in the same way in different locations. These solutions should be implemented on the enterprise level that means not following the separate units' processes but create a unique enterprise architecture which would connect different aspects of the business in one network: from supply chain management, finance and human resources to customers' relationships. Enterprise Resource Planning (ERP) software is one such solution. This software allows accessing up-to-date data about most of a company's activities from a single source. The benefits and strategic importance of such solutions were recognized by the business as well and, according to AMR Research Inc., companies spend up to 40% of total application budget on the ERP (Sweeney & Jacobson, 2007), an enterprise level integrated system is able:

- to standardize the data flow in the company and to reduce the possibility of the inconsistency which can be a result of the point solutions;
- to provide tighter financial control and to facilitate other non-financial reporting activities (e.g. EH&S, CSR reporting etc);

- to give an access to the real-time data from the global perspective;
- to assure more efficient communication between suppliers, manufacturer and customers;
- to give possibility to automate the processes of the records handling;
- to reduce the new product development phase through providing a single source of data for products and services (ibid).

The benefits mentioned above are acknowledged by the experts in the environmental management field. However, studies show that the integration of environmental accounting functionalities in ERP systems is not included in most of the ERPS (71%) (Lang et al., 2005). On the other hand, ERP systems deployment is a continuous process where as resources efficiency accounting as a type of the environmental costs accounting can be a next step. Thus, the discussion on the subject of ERP application will be continued in the section 2.3.1, where aspects concerning application of the software for the environmental purposes are reviewed.

2.2 Role of environmental information for Organization

The attitude to environmental care has been drastically changing in the business environment during the last decade. The environmental management is taken as a way to not only go beyond compliance but also as a part of the differentiation strategy and competitive advantage. However, there are successful companies that use environmental perspective to achieve the environmental cost leadership where they create absolutely new products or services that are beyond the competition (Orsato, 2006). Besides this, the whole approach to environmental management has gone through major modifications: from the consideration of only manufacturing processes and impacts generated, to the life cycle thinking and the accounting of the all value chain. The Life Cycle Management (LCM) is very often taken as a new management system to deal with the increasing demands of the stakeholders to the environmental performance. LCM is “a management system aimed for the collecting, structuring and disseminating product-related information from various programs, concepts and tools” (UNEP, 2007). Basically any of these management systems represent the information processing system with specific steps and procedures. The bigger scope of the system is, the higher environmental information variety is. Moreover, any of these strategies require the extensive accountability as well as for top management as well as for the stakeholders.

Unfortunately there are still many organizations that perceive the environmental management as an add-on to the health and safety management (in the case of the relatively high environmental impact) or as an extension of the quality management (if the environmental impact is relatively low). However, these two approaches aim to manage the complexity in the products and processes within the context of the traditional business environment. According to Lewis (1997) these traditional management systems are not designed to handle the complexity level of the natural environment.

There are various methods and tools which support the retrieving, processing and presenting of the environmental data. For example, *environmental management accounting* tools help to access the data about resources used, waste generated and other environmental costs on the regular basis using the information available in the organization. Then, in order to track the performance and to be able to put targets for improvements, *performance measures* are usually

implemented. *Reporting* is a common approach to present relevant information for the interested parties. A brief overview of these tools and issues related to them are covered in this section in order to provide an understanding of these common used tools and of the complexity of environmental information handling.

2.2.1 Environmental Management Accounting in the business

The environmental management accounting (EMA) is a managerial technology which allows linking the environmental performance with economic results. Basically it is a targeted information collection, analysis and its communication. EMA covers the set of tools from environmental cost accounting and performance measurement till material flow accounting (Rikhardsson et al., 2005). Authors look at the adoption of EMA as on the adoption of managerial technology innovation and distinguish following implementation approaches: an efficient choice, forced adoption or imitation process. From the performed studies they come to the conclusion that *if EMA is implemented by the employees, integrated in information systems and deployed by a large number of the organizations then most probably EMA will evolve in the efficient and effective link between environmental management and management accounting*. If an implementation of EMA is resulting from the imitation process in order to do “because everyone else is doing”, then it will maybe disappear in the short period of time (ibid).

Burritt (2005) provides different definitions of EMA accepted by the various bodies and supplements it with brief historical summary. If EMA is to be compared with conventional management accounting, then we can see the parallel between the purposes where provided information is used for the planning, controlling and decision-making. The main areas where EMA could be useful are identified by Bennett & James (1997) identifying cost reductions and improvements opportunities; prioritizing environmental actions; guiding product pricing, mix and development decisions; enhancing customer value; future-proofing investment and other decisions with long term consequences; assessing the eco-efficiency and/or sustainability of a company’s activities. As it can be observed they are closely related to the core business and can play a vital role for the decision-making. Therefore, it is very important for the business, which strives to follow the sustainability path of the development, to consider EMA implementation, to a certain extent, and not only for the reporting purposes but rather for the use in strategic planning.

Environmental costs accounting (ECA) is a sub-section of the EMA. ECA analyzes aspects of the costs caused, costs avoided and created benefits by the environmental management. ECA is often reflected in the eco-efficiency performance measures, i.e. measures which reveal the economic and environmental performance combined in the specific indicators. Schaltegger & Wagner (2005) emphasize that a major switch has occurred in the ECA during last decade. Organizations move from the conventional perspective, where environmental costs were related to the environment protection activities which cause costs and do not bring any economic benefit, to the approach where environmental costs are defined as a sum of all costs related, directly and indirectly, to the material and energy use. In addition to this, the accounting of the future costs (i.e. due to environmental risks, future environmental costs, budgeting etc) constitutes the significant and one of the most complicated parts of the ECA. Lang et al. (2005) summarize the categorization of the instruments of environmental accounting on *product-oriented instruments* (e.g. life cycle assessment instruments) and *process-oriented instruments* (e.g. EPI, input-output balance, flow cost accounting etc.).

There is no lack of literature and studies concerning various tools and models for EMA. Therefore the purpose of this section is not to describe them or to give an overview but rather concentrate the attention on the identified challenges which are met by companies. Burritt

(2005) examines the problems related to the EMA implementation in organizations. He distinguished two types of the challenges: problems that arise from the conventional management accounting and problems with the lack of the recognition of environmental impacts. The development of software systems is recognized as one of the additional challenges for the future of EMA. *The software systems are essential for the faster diffusion of the EMA within business since it can significantly reduce the maintenance costs and make the accounting processes more efficient.* There is also a need for the distinction of the information necessary for the internal and external stakeholders, where internal performance measures could play important role in the desired behavior change within an organization.

2.2.2 Performance measures

Since one of the research questions of the current paper is related to improvement of the environmental performance of the organization and role of the BIS, it is important to understand what the environmental performance is and how it can be measured. Schaltegger and Wagner (2005), for example, suggest the following definition of the environmental performance: *“Environmental performance is the change of a firm’s environmental impact overtime”*. The change of the environmental impact can be measured by mean of the direct absolute measures and relative measures. Rikhardsson (1998) indicates **five different dimensions** of corporate environmental performance: operations of the company (measures focused on the environmental efficiency and effectiveness of the production processes), products and services (impact on during their life cycle), addressing of the environmental issues by management, measuring the environmental impact from operations and products, and financial dimension of the environmental performance. The International Organization for Standardization (ISO) provides the next definition of environmental performance as *“results of an organization’s management of its environmental aspects”* (ISO, 1999) where these results can be measured against a company’s policy, objectives or targets. Taking into account these viewpoints on the environmental performance of the organization, the Environmental Performance Indicators⁴ (EPI) is a useful set of tools to track any results or change.

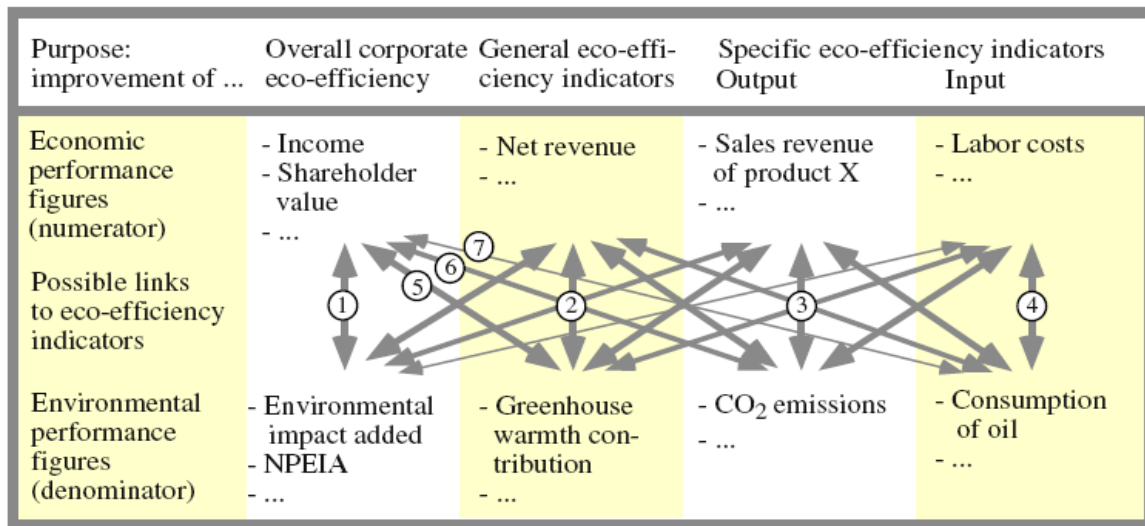
The eco-efficiency measurement discussed in the previous section and indicators that reflect the change represent relative and process-oriented measures. Schaltegger & Burritt (2000) propose the framework for collection of the information related to EPIs (Figure 2-2). They identified different levels of the indicators from overall corporate eco-efficiency to the specific operational eco-efficiency indicators. Schaltegger & Burritt (2000) recommend combining the figures on the same aggregation levels that will make more sense in practice. Scholars emphasize that it is important to develop the indicators which are specific for the certain user, i.e. when they are related to the objects within their area of control. Following examples of possible denominators (i.e. economic value) are given: dollars invested (for investors), product units (for product manager), and machine hours (for engineers controlling a production process) (for the specific examples and focus areas see *ibid*).

Authors call attention to the obstacles which can be met during implementation of the eco-efficiency indicators. They state that the indicators can support decision-making only in the case when they are based on reliable and high quality data and if they are calculated in the same way (i.e. consistent in the accounting approach). Another obstacle is that indicators have to be selected with great care since they can be too narrow or too broad to be able to present valuable information for a specific decision (Schaltegger & Wagner, 2005). Overview of the experience of Swedish companies in the accounting of business travel emissions shows also

⁴ Accepted definition can be found in the Definition section of this thesis

that these two problems are quite common. Organizations struggle to calculate emissions according to the selected indicators in a reliable and consistent way. Indicators changed very often year by year making the performance comparison basically impossible. The high quality data access is another general problem. It is especially relevant for the big multinational corporations where information flows are enormous. The selection of proper indicators is a significant challenge too. In some cases the indicators were completely not useful in terms of reflection of the actual company's performance (Makarova, 2008).

Figure 2-2 Systematic collection of eco-efficiency information⁵



Source: Schaltegger & Burritt (2000)

Lang et al. (2005) state that if EPIs are provided on a regular basis they are able to promote continuous improvements, compliance and to provide the information for mandatory or voluntary reports to interested parties. However, scholars (ibid) also identify the two types of issues related to the environmental information:

- Environmental information usually **generated and interpreted by experts** and EPI can be difficult to understand for other managers in order to take a decision. To overcome these problems there is a need to set up the proper structure of this information using Environmental Accounting Instruments;
- Environmental information is often **generated separately from other business information**. Hence, the integration of this information in the IT infrastructure is a way to involve the relevant people in the organization.

2.2.3 Reporting

Reporting is an essential part of the communication of the company's activities. The different types of environmental reporting can be distinguished, where mandatory reports about legal compliance and voluntary non-financial reports are the main groups. However, pure environmental reporting is declining with each year, and "sustainability" or "corporate responsibility" reports take a major fraction of the total non-financial reporting activity

⁵ NPEIA = net present environmental impact added. This framework is an illustration only. For more detailed information look at work of Schaltegger & Burritt (2000)

(Corporate Register). According to statistics, by Corporate Register, 81% of the FTSE100 companies⁶ provide separate CSR/sustainability/environmental reports. Various reporting guidelines are used by companies such as Global Reporting Initiative (GRI), Carbon Disclosure project, AA1000AS and Global Compact. In addition to the variety of reporting tools, all of them also have different performance indicators and required data. Certainly it is difficult for companies not only to choose the most suitable reporting tool, but also to collect all relevant information. Moreover, most of the reporting initiatives impose a certain level of quality for the presented information. For instance, GRI has a set of principles that define the report quality where balance, comparability, accuracy, timeliness, reliability, and clarity are among them (GRI, 2008). Therefore, besides the need for systematic approach for obtaining necessary information with regard to the performance, third party assurance is becoming more common practice to guarantee the quality and reliability of the data. The increased credibility of the reports is one of the main drivers for third party assurance. However, some companies choose the stakeholders involvement for assessment of the statements and information or simply follow accepted reporting guidelines (e.g. GRI) (Park & Brorson, 2005).

General verification process consists of qualitative and quantitative checking, where random spot checks can take place. According to the CSR Assurance statement report, were assurance statements from the last 15 years have been analyzed, checking of the Data Systems and Internal interviews are the most used assurance methodologies. But the assurance process meets some difficulties, which are related to the absence of common guidelines for the collection, evaluation and reporting non-financial data. In addition to this, there is no generally accepted approach to non-financial assurance. As a result, many of the assurance statements are rather vague and referred to as “Opinion statement” (CorporateRegister, 2008). Nevertheless, the situation with assurance standards will change quite soon, and companies will need to be more careful about the data presented and its verifiability.

2.3 The strategies for integration of environmental information flow in an Organization by means of Information Technology

This section has a purpose to explore the area where the answer of the question, raised in the background section, could be found, i.e. **how can environmental information flow be integrated into the Business Information System in such a way that environmental performance will be improved?** An attempt to provide an overview of possible approaches for environmental information integration is done in the current section. It comprises the issues brought by both research questions. Looking at the integration aspect, there are different ways to achieve it. It is possible by means of acquiring specific environmental software that provides the functions of collecting necessary information, and further its integration. However, as it has been emphasized in Section 2.2, Environmental Accounting (EA) is a vital constituent of the improvement, then it is rational to study possibilities for integration of EA into the BIS. Another way to consider the environmental performance measures in the IS/IT solutions is to embed the environmental sustainability thinking into its development. The latter two approaches slightly differ from each other. Nevertheless, both of them propose to expand the functionality of the business information systems. The importance of this aspect has been emphasized in Section 2.1.1.

Though, the research area of environmental sustainability of information systems is not explored well, there are some publications that concern this issue. Standing & Jackson (2007)

⁶ The FTSE 100 Index (abbreviated Financial Times Stock Exchange Index) is a share index of the 100 most highly capitalised companies listed on the London Stock Exchange (http://en.wikipedia.org/wiki/FTSE_100_Index)

provide sustainability principles that should be considered while IS is been developed and deployed. The principles cover all information system's life cycle: from planning to follow-up and change implementation. Authors suggest the number of aspects to be reviewed for decision-making on each stage of the life cycle. Standing & Jackson (2007) emphasize the importance of considering future needs and involvement of the stakeholders. The environmental aspects are covered from different viewpoints: from the requirements of equipment purchasing to the design of systems for minimization of waste. They also propose to use the generic maturity model for the assessment of sustainability performance of the IS, which has been developed by the IT governance institute (ITGI, 2008). Haigh & Griffiths (2008) used the multi-disciplinary approach, similar to the current study, where interaction between organization and information system, organization and its environmental performance and environmental impact of the IT are studied. However, the main focus of the work, by (ibid), has been on the resource consumption of the business information system. They basically studied the issue: do information technologies really help to reduce the resources consumed. Scholars used following resource consumption metrics: time required, number of people involved, sheets of paper consumed, amount of time computers were used.

Certainly it is important to take into account resources necessary for the operation of an IS, including those that are used in the use phase, such as electricity, time or paper. However, the issue when IS can be applied to reduce resource consumption from other processes has larger opportunities for influencing the overall environmental footprint of the organization. In this case, considering the issues discussed in the previous sections, where the complexity and challenges of environmental work in the organization and benefits from the Information Systems are discussed briefly, the notion about the integration of environmental information management and BIS is becoming more apparent. Following IT strategies for the integration of Environmental Accounting functionalities into BIS are identified in the literature (Rikhardsson, 1998): *office application approach*; *using enterprises information systems (EIS)*; *using Environmental Management Information Systems (EMIS)*; *data warehousing*. Since office application approach has limited functionality and encounters problems with data update and exchange, EMIS and data warehousing will be "explained" in this section. In addition to this, a brief overview of the environmental software is provided, where certain aspects related to the integration of EIS are discussed.

2.3.1 Environmental Software and its use in an organization

The environmental software is a category of software applications specifically used for the purpose of handling environment related information. Most of them are stand alone applications performing a particular task that can be faced by the organization, e.g. permits management or life-cycle assessment software (see Table 2-1 for the general overview of the main categories) (Moore, 2002). Very often this software is used as a tool for the compliance with environmental law and regulations, and rarely for determining the areas for improvement or estimation of the financial aspects of environmental management (Rikhardsson, 1998).

Table 2-1 Categories of Environmental Software

Software Categories	Brief Description
Mass Flow and Process Flow Software	helps the user develop a process or mass flow diagram that depicts the sequence of operations for all products. Supports data for heavily regulated facilities at the operational level; very narrow focus on environmental data
Waste Management Software	manages data for hazardous waste - from profiling and manifesting to calculating, monitoring, and tracking at the operational level
Permit Management and Material Safety Data Sheet (MSDS) Software	offers processing, tracking, and reporting support for permit submission and monitoring compliance status
Environmental Standards, Law, and Regulation Tracking Software	offers full text of environment-related laws and regulations. Often includes guidance and comments. Subscription based, but can sometimes be customized for an organization based on their specific products
Health and Safety (H&S) Software	helps manage government health and safety regulations, workplace assessments, project management, and incident reports. Can link to environmental modules of leverage environmental data sources
Environmental Risk and Impact Assessment Software	identifies and assesses risks and impacts associated with activities at the site level. Focuses on discrete, occasional, and accidental events; helps calculate probability or frequency and consequences. Uses a rules-based approach to assessing direct and indirect impacts of an activity
Life-Cycle Assessment (LCA) Software	Links environmental interactions to environmental effects in order to assist managers in assessing the environmental impacts of each stage of the life cycle of a product, from raw material extraction through transport, design, development, sale and take-back. Often referred as "cradle to grave"
Environmental Simulation and Modeling Software	graphically portrays environmental interactions and outcomes. Geographical information systems (GIS) is a popular application that helps managers visualize impacts, and how they interact or react in different scenarios
Environmental Management System (EMS) Software	used for implementation of environmental management standards - for example ISO 14001 or EMAS. Managers may use it to create a compliance blueprint and detail task/activities per elements of the standard. This often includes tracking, managing documents, scheduling, and monitoring tasks for each element
Integrated and Modular Software	may include one or more of the systems mentioned above, integrated within larger IT framework that could be Web-based. Most commonly the data from the above-mentioned systems are transferred into an enterprise-wide resource planning (ERP) system, such as SAP
Web-based Environmental or EH&S Management Systems	provide EMS and EH&S support entirely via a Web-site. The ASP model charges a subscription fee per module or per user. The purpose is to provide easy access to a support that is entirely out-sourced

Source: Moore (2002)

However, this trend is changing in the business environment. For instance, the report about Life Cycle Management (LCM), prepared by UNEP, reveals some of the successful practices of various software tools used on every life cycle stage by the most proactive global companies. For instance, SEEbalance®, an LCM tool developed by BASF, allows performing a comprehensive analysis of the product's life cycle from the angles of the end customer, with environmental, economic and social aspects with equal weight in the assessment. Other specific environmental software is developed by ESP, a U.S. based company. The product range consists of the software for compliance management, GRI reporting, emissions monitoring and accounting (ESP, 2008a). The presented case studies give an overview of the challenges that were met by the companies before implementation of specialized software and benefits obtained. The largest global companies are among the customers of ESP, therefore they had similar problems with document handling such as different format and templates of the various facilities; no unified reporting activity; access to the data is difficult for external stakeholders not related to the manufacturing facilities, e.g. top management or other departments; and low functionality and flexibility. The software provides a number of positive outcomes, where common database, standardized data collection, streamlined calculations, understandable and configurable layout are among the most widespread. For instance, General Motors states that they were able to achieve 35-45% reduction in the efforts necessary for air emissions reporting according to U.S. regulation (ESP, 2008b). However, the main driver for the implementation of the software is still compliance with regulation or other voluntary reporting initiatives, as it has been noticed also by Rikhardsson (1998). Nevertheless, the issue of efficiency and effectiveness of such applications has been recognized in all cases. Besides reduced time spent on data collection and reporting, mentioned above, there have been observed reductions in on-site audits, facilitated initiation of preventative measures, better transparency of operations, and increased consistency of data. Nevertheless, there is software applications developed and used for "beyond compliance" and strategic activities like eco-efficiency, product stewardships and even for sustainable development with social aspects included (El-Gayar & Fritz, 2006). Software for Material Flow Management, reviewed by Mayer (2001), can assist in the transparency of material flows or even relating it to the costs, thus helping to identify the least eco-efficient processes or products. Other examples of the environmental software can be found in the web-based database developed by Donley Technology (Donley Technology, 2008).

The Enterprise Resource Planning Systems (ERPS) constitute a separate category of environmental software. However, despite its wide application discussed in Section 2.1.2, the companies rarely see its environmental potential. Strategic situation analysis in the enterprise by Molloy (2007) reveals that mostly MS Office applications are used for environmental management. Even though there is a lot of information stored in ERPS, it is not available for the environmental manager. However, this potential has been recognized in the research field, where active work on the deployment of ERPS for extraction and communication of environment related information has been done since about 2001 (Hutter, 2001; Lang et al., 2005; Schulze, 2002; Wohlgemuth et al., 2004 etc). For instance, ERP has been recommended as a source of data for Resource Efficiency Accounting method developed by Wuppertal Institute, where financial information about costs is supplemented with material intensity index (MI). In the frame of the CARE project (Computer Aided Resource Efficiency Accounting for Medium-Sized Enterprises) three case studies were performed, where Toshiba Europe GmbH (computer assembly), Nolte Möbel (furniture), Muckenhaupt & Nusselt GmbH & Co (cable) were among studied companies. ERPS can be used not only for the extraction of data about materials flows or costs, but is also able to communicate the processed data in other systems like EMIS (see Section 2.3.2) (Beucker et al., 2002).

2.3.2 Environmental Management Information Systems

The concept of Environmental Management Information Systems (EMIS) appeared in late 90s and has been through various modifications (El-Gayar & Fritz, 2006). Basically, the definition of EMIS is from the definition of IS (see Definitions at the end of the document), but the type of information is specified: it is environmentally relevant, i.e. the information necessary for the management of environmental impacts in accordance with company's strategy and requirements of the stakeholders. Therefore, EMIS can include quite wide range of systems: from stand alone applications and decision-support systems, reviewed in Section 2.3.1 to enterprise integrated information systems discussed in Section 2.1. Consequently, this section explores the general strategies for the integration of environmental information management in the business information systems.

Unlike the topic of environmental sustainability of IS, deployment of EMIS has been studied in a more elaborated way. Rikhardsson (1998) suggests what the “ideal information system for supporting environmental performance measurement” should cover. The criteria support the five dimensions of the performance measures mentioned in Section 2.2.2. (ibid) provides the categorization of data types (input and output) and proposes an implementation process for an Environmental Information System. However, the overview of IT support and Environmental Data is heavily based on Microsoft Office applications such as Excel or Access, still common in many organizations but has limited functionality in large and global companies. In general, the recommendations are waste management oriented and proposed financial environmental performance is related to the costs of waste management or regulation compliance. While Moore (2002) emphasizes the importance of the purpose of the information system and marks out two ways of EMIS implementation: technology-led and strategy-led. In the case of **technology-led**, environmental software is used to improve efficiency of the processes or to comply with regulatory requirements reducing redundancy related to data collection and reporting. The **strategy-led** approach, aims to shift from the command-and-control management towards using information technologies for competitive advantage of the organization. From this point of view, EMIS is seen as more than just a technical tool for data collection and reporting. It is the System which is able to influence the corporate and environmental management strategy at many levels (ibid). Molloy (2007), for instance, proposes to use the strategic IT planning process for strategic integration of environmental management in the IT infrastructure, where *strategic situation analysis*, *strategic target planning*, *strategy development* and *strategic action planning* are core sub-processes.

Most of the research proposes EMIS deployment from the “consultative” perspective, i.e. when the EMS is analyzed first and the needs for information are identified, after that, necessary IT solutions are determined. This approach requires the combination of EMS expertise and software or IT expertise, where the following qualifications are valuable: proven experience in environmental management, environmental policy, auditing, compliance management, information management, geographical information systems (GIS), multiple IT platforms and methodology for environmental e-business (Moore, 2002).

From the technical viewpoint, there are four types of EMIS strategies (ibid):

- Use internal and external resources; build an EMIS from scratch (Customized System);
- Re-engineer an existing system (e.g. an accounting system) to accommodate environmental information (Customized System);

- Develop an EMIS through enhancements and adaptations to existing systems without reengineering (Customized System);
- Buy and implement off-the-shelf or standardized EMIS (Off-the-shelf Packages).

For example, according to the study done by Mock and Schroeder (2002) (as it is cited in (El-Gayar & Fritz, 2006)), 30% of respondents use commercial off-the-shelf (COTS) systems, e.g., Enviance systems, VisionMonitor Operational Intelligence, and Dixon Environmental, while 47% use customized systems, and 22% use spreadsheets and commercial databases, e.g., Oracle and IBM's DB2. Looking at the benefits and costs related to the deployment, the third strategy would be most favorable for a large organization, since there are already many different Information Systems in place and knowledge and experience exist. However, the most important identified drawbacks are clear identification of the requirements of information and selection of the system integration strategies and candidates (Moore, 2002).

In relation to other technical issues, data management, decision support and integration with other systems have been highlighted in the work of El-Gayar and Fritz (2006). The particular characteristics of the environmental data, such as high distribution in time and locations, when different region-specific formats are used, the size of data, and heterogeneous data management with use of different software and hardware, should be taken into account during the EMIS design. The problem of integration with other systems could be solved with deployment of web services, eXtensible Markup Language (XML) and other techniques (ibid). The portal technology, as a single source of access and transformation of the environmental information, is discussed by Moore (2003). The author also indicates the types of environmental information flow on lateral and vertical levels where the created Information Matrix can facilitate organizing the inputs and outputs of the portal (see Appendix II). Other use of web technologies has been tested by Kästner (2007). Three different solutions for the switching of environmental information management from MS-Access to web-based application by means of PHP and MySQL, direct PHP and Java Server Pages are reviewed.

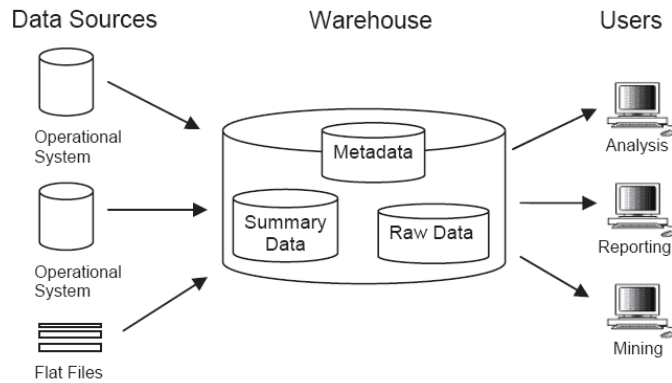
Good integration of environmental information and its availability can facilitate the reporting activities. Customized reports can be generated whenever it is required by any stakeholder: either by an employee about his own environmental impact or the process operated by him/her, or reporting for the investors. The subject of e-reporting and its benefits is widely discussed by researchers (Goscimski, 2007; Grünwald & Gómez, 2007; Isenmann & Lenz, 2001).

2.3.3 Data Warehousing

The importance of the single source of updated and reliable data is emphasized by all scholars who study Environmental Management Information Systems (EMIS). It is especially relevant in the case of fast growing and multinational organizations, where each site has its own EMS and monitoring system. There are different ways to integrate EMIS in BIS. One of the possible modes is to assure the relevant information flow in enterprise information systems, like ERP, as discussed in Section 2.1.2. The development of accessible single sources of information is another mean. This approach has been covered partially in the section above, where significance of the portals and web-applications was mentioned. Data warehouse represents the way to integrate the environmental information providing single source of it. Data warehouses are also seen as the IT platform for EMIS, where other types of platforms are Meta-information System and Virtual Database System (Moore, 2002). The important feature of the data warehouse is that it does not only collect data from various systems and structures it, but also is able to provide the information in such a way suitable for the

respective use, e.g. to facilitate decision-making, and can be used for analysis, reporting or data mining (Burmam & Gómez, 2007) (see Figure 2-3).

Figure 2-3 Architecture of a data warehouse



Source: Burmann & Gómez (2007)

The experience of Burmann & Gómez (2007) in the implementation of an environmental data warehouse at Volkswagen AG shows that the environment related data necessary for the calculations of impacts can be found in other non-environmental systems, like systems for process planning. Therefore, it requires careful overview of the numerous systems in order to find necessary data. For this purpose, they mapped existing environmental information systems in accordance to process- or product-related systems. Some other challenges are identified also. Obtaining of necessary relevant information is recognized as one of the most time consuming and complicated tasks. However, authors state that the benefits from the data warehouse outweigh the problems that might occur. The main benefits are *reliable and verifiable data*; *possibility to assign the emissions to the source*, i.e. product or process, and not only to the production unit (e.g. amount of the emissions per product produced) due to combination of the data from various systems; *reduced time for the collection of the information* for sustainability reporting and thus costs related to it (ibid).

The experience of Hutter (2001) in the deployment of Environmental Business Warehouse (EBW) based on ERP software in Hewlett Packard supports the benefits obtained from implementation of single source environmental data. The author also states that EBW facilitates the integration of environmental matters in strategic decision-making and daily business of the company. While Chu et al. (2002) describe the framework of environmental data warehouse emphasizing the aspects of environmental data quality management. Research proposes the systematic approach for data quality assurance, depicting four main phases necessary for it: analyzing data quality requirements, constructing attribute-based metadata, identifying data quality, performing cost-benefit evaluation to meet the goal “fit to use”, i.e. to use only the most suitable data.

2.4 Conclusions derived from literature review

First of all it is important to emphasize that the section of literature review aimed to provide an overview of the research area through lenses of the multi-disciplinary context framework (Figure 1-1). This approach has been used to analyze the experience related to the various interactions between main elements and thus, give a basis for the answer of the first research question, i.e. *How can Business Information Systems (BIS) help to improve environmental performance of organizations?* An attempt to explore the field, connected to the integration of business IS/IT solutions in the organization, has been also completed, where the main research gaps and

problems were found. In order to summarize relevant with the research question conclusions, they will be grouped in accordance with strategic IT planning process for strategic integration of environmental management in IT infrastructure, proposed by Molloy (2007) and covered in Section 2.3.2 of the research work. This set up can also assist companies in the identification of problems that can be met at each stage of integration.

Strategic situation analysis

It has been confirmed that business information systems can enable change in an organization, including behavioral. However, it is not enough to only have IS to make any action towards change effective. Therefore, in order to pursue any changes in the organization, including improvement of environmental performance, it is important to understand clearly the organizational structure and drivers behind the corporate strategy. In addition to organizational parameters, cognitive characteristics of the IT system's users should be taken into account.

Concerning the environmental matter, there is still a lack of recognition of its importance. This is especially typical for organizations and departments with relatively low environmental impact, as IT for example. Thus, the environmental management and its support are often omitted by the IT professional, mostly because of the complexity of issues and deficiency in environmental expertise, e.g. knowledge about environmental impacts of processes where IS are deployed or about problems with environmental data collection necessary for improvement or reporting. It is important to remember that environmental care is not only the costs, but more the opportunity to be more effective and efficient reaching the optimum and avoiding redundancies.

As for the environmental data, it is still widely used for compliance reporting, either according to legislation, or to voluntary initiatives. However, availability of data is a prerequisite for the more superior and strategic improvements and it has been recognized that IT is very essential for the assurance of this availability. *Thus, since the information is necessary for the improvement of the organization's environmental performance, and information systems are able to provide this information in an **efficient and effective** manner, we can state that BIS can improve the environmental performance through assurance of environmental information availability.* Besides this, since BIS enables change in the organization by means of changing the way how processes are performed and increasing awareness, *BIS is able to support the more effective integration of environmental care in the business.*

In order to proceed with any incremental changes in the IT infrastructure for environmental performance improvement, first of all it is necessary to analyze the situation with existing systems integration, including those that are specifically designed for environmental purposes, and identify main success factors and gaps, so called **“as-is analysis”**. It is derived from the notion that there is already relevant environmental information in existing systems.

Strategic target planning

Regarding the strategic target planning, before initiation of any changes in BIS, it is important to specify the purpose of sought environmental information, i.e. is it required for compliance reporting and communicating, or for the competitive advantage of the enterprise. This information is necessary for the development of specific Key Performance Indicators, further follows up-s of the system's performance and formulation of the target **“to-be” situation**. According to the literature review, EPIs are found as an environmental instrument that supports the largest number of environmental management tasks, but have to be related to business information in order to be effective and to be used for informed decision-making. A

well-developed set of EPIs for the different organizational levels and various stakeholders would facilitate the search for necessary raw data in existing systems. On the operational level, EPIs assure consistency, transparency and reliability of the data. But in any case, the following factors in environmental management must be supported by information systems: enhancements of transparency and identification of cost advantages and disadvantages (Molloy, 2007).

Strategic development

This section is more related to the question of how to integrate environmental information flow in the BIS. Different strategies of environmental accounting as well as environmental management integration were discussed. However, they all concern the availability and processing of environmental information. Developing strategy for environmental management information systems deployment, it is essential to keep in mind core requirements suggested by Moore (2003), where the *single point of the adequate and reliable information in a timely manner*, ensuring *the cost-effective and transferable solutions* that can be applied to other business processes or other sites and *prioritizing* information, process, procedures and the system itself are some of the requirements. These requirements aim towards the development of an efficient information system which would foster the communication and collaboration between stakeholders and would create a system which is able to assure continuous improvement.

Concerning the technical features, it is difficult to create the EMIS based on a single platform, as in the case of ERP. It should function across all organization on different levels and manage very wide range of information, from emissions and documents necessary for compliance with regulation to the data used for innovation and strategic decision support. The complexity of such systems will only grow in the future, adding new functionalities. Therefore, it is important to create “organismic” systems which would be able to adapt to the changing environment with time, where system’s architecture foresees future needs. Nevertheless, in the case of highly developed IT infrastructure, it would be beneficial to adapt existing systems, where expansion of BIS’ application should be the primary interest. It is important to remember that integration of EMS in the BIS has the same technical problems as any IT system. The same quality assurance criteria should be applied to it. Existing experience for the development of the EMIS should be used when any of the business information system is deployed.

In general, the integration of Environmental Accounting into Business Information Systems is discussed a lot and there is a sufficient set of materials necessary for the development of such systems. However, EMIS is seen very often as an accounting system, i.e. standing alone but integrated with other systems. EMIS as such is necessary, though it’s essential to assure the generation of environmental information in every business IT solution where it is relevant and possible, after which the information may be collected in the EMIS through ERP, portals or data warehouses.

Strategic action planning

Considering the range of environmental information to be handled and the existing technical possibility for its extraction and collection, it is essential to emphasize the importance of effective communication of this information and use of it for strategic purposes. Stubbs (1994, as it’s cited in Moore, 2002) states *“IT systems can automate the collection, analysis and communication of environmental data on an organization’s behalf, but organization must have the mechanisms and culture necessary to enable it to learn how to turn those data into information if they are to be used to guide actions which promote sustainability”*. Therefore, during the strategic planning of its integration it is

important to look not only at the technical possibilities of the IS/IT solution, but also at the overall environment where the system operates, including the users. It is highly recommended to involve strategic users from the beginning of the integration activities, and then the combination of skills will be assured.

As a concluding remark, research emphasizes the need to consider sustainability thinking when Information Systems are deployed, but rarely sufficiently practical tools are proposed. Most of the research works are related to the integration of EMIS in the BIS or suggest the possible environmental data sources in existing enterprise systems. They are concerned more about the issue of efficiency, rather than further effective use of the generated information. In other words, the organizational parameters are rarely taken into account. In most of the cases the recommendations are quite general and don't provide a clear framework for the achievement of environmental viability of information systems bringing tangible improvements to the organization's performance. Also there is not much information about how to develop the business IT solution with built-in environmental perspective. Besides this, the lack of attention to Environmental Management from researchers in Information Systems and the lack of theoretical approach to environmental information management systems have been noticed.

Therefore, current research and following sections will provide an attempt to cover these research gaps through application of scientific theories, and where possible, **criteria for the deployment of efficient and effective environmental information flow in the organization's information system** will be sought.

3 Information Processing in Organization – a Review of Theories

The examination of the applicable theories is very important for the research design as well for the support of the findings. 2 cybernetics theories and 1 organizational theory, which are discussed in this chapter, are accepted and used in the management and the information processing studies. Therefore, the knowledge behind them can help to identify the key elements of the effective environmental information system. The application of these theories for the current research will be discussed in the section 3.3, where logic and relevance of the theories will be explained. The section 3.4 provides the theoretical framework based on the Viable System Model which is used for the analysis of the collected data about IS/IT solutions.

3.1 Cybernetics theories

Understanding of how systems operate is very important for various disciplines: from medicine to management, since any “living” object can be viewed as a system with its rules and communication means. System thinking is widely used also in the sustainability studies, where learning of the interactions among elements and sub-systems constitutes the major part of the knowledge that is necessary in order to move towards sustainable development. Though the system approach is relatively young concept and has been developed during the last 50 years. It comprises a number of various “schools” of system thinking such as General System Theory, Cybernetics, Operations Research and Systems Engineering, Systems Analysis, Soft System Methodology and Critical Systems Thinking (Olsson & Sjöstedt, 2004).

As a part of the System theories Cybernetics theories aim to explain the system’s functions, coordination and control of system’s elements, as well as deal with communications between subsystems. The cybernetics principles are widely applied also in the business and management studies. Ashby’s Law of requisite variety and Beer’s viable system theory are the most used and accepted for the organizations studies (Qu at al., 2008). Furthermore, the aspects of the information management within the organization can be supported by these theories.

3.1.1 Ashby’s Law of requisite variety

“*Only variety can destroy variety*” states the law formulated by W. Ross Ashby, psychiatrist and pioneer in cybernetics and described in his book “An Introduction to Cybernetics” in 1956. On the Beer’s opinion this law “stands in management science as Newton’s Laws stand to physics; it is central to a coherent account of complexity control” (Beer, 1984). Though, the law, and especially its application for management and information processing, can be difficult to comprehend for the uninitiated reader. Therefore many different formulations and interpretation can be found in literature. One of the accepted formulations is “the higher the “variety” possessed by the system, the higher the capability of the system in handling its environment” (Qu at al., 2008). In the business application it can be explained in the following way: every organization operates in the certain environment, and in order to cope with almost indefinite states of the environment, which is changing all the time, the organization should flexible as much as possible. And to have control over the environment, variety possessed by the organization should as great as or larger than variety in the

⁷ This “environment” is different from the natural environment, thus it is important for the reader to distinguish organizational environment and natural environment.

environment. From the view of the information, the degree of the system's controllability can be defined as the amount of the information in control system (ibid).

Supply chain management is one of the good illustrations of the application of this law. The supply chain has very large variety, i.e. states of the system, because of very large number of suppliers in the different tiers like in the complex industries as automotive. In addition to this, the conditions in which they operate are continuously changing. It brings a high uncertainty for the manufacturer hence there is higher risk imposed. Therefore, in order to facilitate the control over supply chain, there is a need to possess this variety in the same extent, e.g. to increase the amount of information about suppliers and their environments in the system.

3.1.2 Beer's Viable System Model

Viable System Model (VSM) is the result of 30 years of work done by Stafford Beer. VSM has been developed taking into account the Ashby's law of requisite variety discussed above. The basic purpose of the model is to describe how systems maintain their viability, i.e. capability for the independent existence (Beer, 1984). This viable system is called also as self-organizing system. VSM represents the framework which can be used for the analysis of any system in order to determine the causes of failures and the ways how to overcome them. A number of principles of organization, theorem, axioms and laws have been developed and form the rules for the viable system (ibid).

The viable system formed by the five-fold systemic set, where these 5 sub-systems interact and influence on each other. **System 1** is fundamental operational system which is always viable system in itself, since it also has the same structure. Basically it reminds a Russian doll where every system is inside of another system. This phenomenon is known also as recursion. System 1 includes all operations that justify the existence of the system. Every element is connected to its own environment, and those environments may be either entirely separated or overlapped. **System 2** serves for the Co-ordination of the operational elements in System 1. It provides regulatory function and as an example from management, the planning and objectives are part of the System 2. **System 3** is control of immediate activities of the System 1 and fulfillment of the regulation (e.g. plans). It can be audit or monitoring. System 3 is a vital link between management and operations and provides necessary for the control information. The law of requisite variety is very important for the effective functioning of this system. **System 4** has the role of the intelligence and connected directly to the environment. Only this system has possibility to evaluate overall variety and uncertainty since every single operation in the System 1 has an access only to its own environment. System 4 helps to adapt all viable system to the changes and closely connected to the control System 3 with very reach interactions as a prerequisite for the viability. The function of system 4 is normally fulfilled by research and development department. **System 5** monitors the interaction of System 3 and System 4, maintaining the balance between the management of "here and now" and management of "out there and in the future".

VSM is often applied for the analysis of the effectiveness of the system, and information management in particular. For example, Espejo & Watt (1988) explored the obstacles that can be met in the information management within organization, and converting of the information into effective actions. Using VSM they proposed 3 possible strategies to achieve necessary match of the information-processing capacity of the managers to the great amount of the information implied by their responsibilities and commitments. The study of Lewis (1997) analyses the environmental management of manufacturing organizations from a systems perspective and gives suggestions concerning necessary changes in the organizational structure and management practices. Lewis (1997) came to the conclusion that business strategies will

be likely driven more by the cooperation than by the competition and that companies will put more efforts in organizing their supply chain instead of products and markets. After a decade we already can observe the predicted changes in the corporate strategies. Especially significant shift is happening from the environmental care viewpoint.

3.2 Organizational Information Processing theory

Organizational Information Processing Theory has been developed by Jay Galbraith in 70s. It is very closely related to the Ashby's law of requisite variety and basically reflects it from the information processing perspective. There are 3 main concepts that comprise the theory: **Information Processing Needs (IPN), Information Processing Capability (IPC) and fit** between them. This fit is a condition for the well performing organization. Therefore, *the organization has to obtain the necessary information processing capability in order to deal with information processing needs*. Deriving from this statement, it is important to know what actually can influence the IPN. The main influencing factor is the level of uncertainty the unit is subjected to. According to work of Tushman and Nader (1978) the sources of uncertainties are: *subunits task characteristics* (task complexity and task interdependence), *subunit task environment* and *inter-unit task interdependence*. In other words, the more complex task is, higher dependence of the operations from other units and more uncertain conditions in which unit operates the more need for information processing is.

As for the IPC, Tushman and Nader (1978) also provide the aspects which can have impact on the organization's processing capacity. IPC will depend on is *the design of subunits organismic or mechanistic*, and on existence of *the feasible set of coordination and control mechanisms*. These aspects could be referred to the following examples of structural variables: formalization, centralization, leadership style, degree of participation, lateral and vertical communication and distribution of power and control. For example, organismic structures are characterized by high connectivity of the networks, involvement of the personnel into decision-making process, less formalization, rules and regulations. This flexibility allows dealing with greater level of uncertainty. However, higher IPC is, higher costs and complexity of the management are. The IPC of the organization or unit has to be taken into account when information channels or information system is designed. Therefore it is very important to find the balance in IPC and achieve the "fit". The consideration of these aspects may influence of the success of the IS and effective information processing.

If we look at the example of the supply chain management and analyze it from the perspective of IPT, we will see that the process and task itself can be described as very complex with very high level of task interdependence and inter-unit task interdependence. In addition to this, as it has been mentioned in the discussion of Ashby's Law, there is high level of environment uncertainty. Thus, we come to the conclusion that there is a high information processing need. According to IPT, there are 2 ways to deal with high uncertainty and high IPN: it can be done either by means of the reduction of the number of the supplier and therefore the complexity of supply chain, or by means of the establishing close communication links with sufficiently great amount of the information about suppliers.

In fact, this theory is quite often used for the studies related to the information processing in the supply chain management, its inter-organizational communication and information flows (Kyung Kyu et al., 2006; Bensaou & Venkatraman, 1995; Premkumar et al., 2005; G. Qu et al., 2008; Zhong et al., 2007). It basically illustrates the strategic importance of the information in the supply chain management. Most of these studies use the Information Processing Model (IPM) developed by Tushman and Nader (1978) with some modifications (see examples in the Appendix III).

Kyung Kyu et al. (2006) using the IPT proves that “the more is not always better”. It is related to the assumption that the higher electronic integration for the information processing higher organizational performance is. They stress the importance of the “fit” looking at the B2B procurement in the automotive and shipbuilding industries. The study of Qu et al. (2008) also supports this conclusion and emphasize the importance of use of IS and IT in general for the coordination and handling uncertainty. While in the work of Bensaou & Venkatraman (1995) IPM has been applied in order to classify configurations of fit in inter-organizational communication in the automotive industry, where the level of integration of electronic data interchange has been one of the distinguishing factors. Most probably, considering the trends in the manufacturing industry, electronic interdependence and electronic control will be the most common configurations in order to achieve the fit between IPN and IPC. They are characterized by extensive use of IT for the data exchange. Premkumar et al. (2005), in their turn, explored the influence of the “fit” on the performance of the procurement department. The results show that interaction between IPN and IPC has significant effect on the performance.

Other application of this theory has been found in another empirical study of Fairbank et al. (2006) where the relationships between IT and organization’s performance have been examined. Unlike Bensaou & Venkatraman (1995), IT has been analyzed not from the resource use perspective but rather from the information processing design choices. There are 2 choices distinguished: related to the organizational performance, i.e. cost-efficiency perspective, and to the strategic posture. The research concluded what all studied companies benefit from use of IT in order to increase cost-efficiency, however organizations shouldn’t forget about the importance of IT for their strategy.

3.3 Relevance of the theories for the current research

The argumentation of the relevance of these theories for the specific topic of the current research paper is based on its principal purpose and targeted research questions. The first research question states following: **“how can Business Information Systems (BIS) help to improve the environmental performance of organizations?”** Therefore it is important to know how the environmental performance could be assessed. From this viewpoint, the work of Lewis & Stewart (2003) can be an interesting perspective of measuring of the performance and the balance between “green” and commercial performance, i.e. the sustainable business performance. Both types of the performances are measured by ability of the organization to handle an uncertainty that basically means the amount of the information possessed necessary to develop sufficient decision-making capacity. Ashby’s Law of requisite variety has been applied in this case. Therefore we can make first assumption, *to improve environmental performance of the organization there is need to provide environmental information processing capacity.*

Measuring the effectiveness of the integration of the green issues into the business strategy Lewis & Stewart (2003) also came to the conclusion that possessing of the organizational variety in the natural environment is difficult, expensive and time consuming. It’s especially peculiar to the large organizations and those who possess Environmental Management System (EMS). Since the role of the Information Technologies as a mean to reduce the operational and transaction costs is widely recognized by the business and scholars, next assumption can be made: *deployment of IS/IT for the processing of the environmental information is a way to make the integration of the environmental concern more efficient.* Thus, combining these assumptions we come to the answer on the research question: **in order to improve environmental performance of the organization BIS has to be able to collect, to process and to handle the environmental information of the organization in the efficient and effective way.** It is one of the applications of the Ashby’s Law for the current research. Even though this

statement sounds rather obvious and as a common sense, the important point that we came to this conclusion by two different ways: through the experience from the empirical studies reviewed in the Chapter 2 and by means of the argumentation supported by scientific theories.

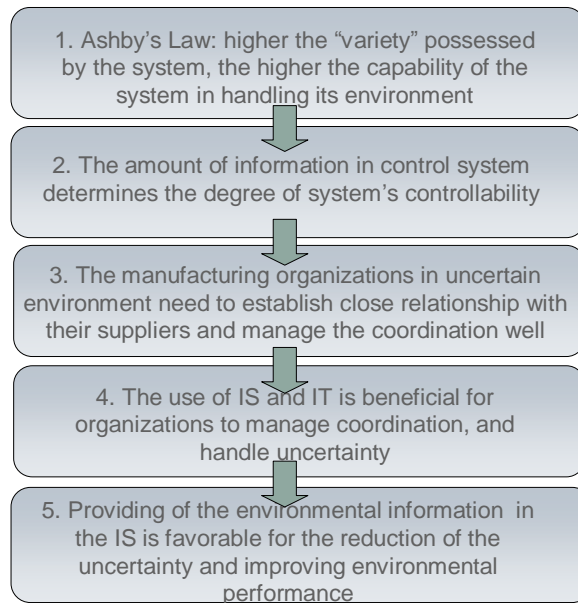
If we look at the second research question: **“How can business Information Systems and Information Technology solutions be integrated in an organization to improve the environmental performance in terms of efficiency and effectiveness?”** *the knowledge of the process*, where IT solution is implemented, and *the purpose of the IT solution* are essential. The Information Processing Needs (IPN) concept could be helpful for **the selection of the process**, where the information need is highest. Highly complex, dynamic and processes with high task interdependence have biggest uncertainty of the environment, hence high information processing need. In this respect IPT proves the appropriateness and the relevance of the focus area for the current research. Process of purchasing in the Global automanufacturing company with large variety and complexity of the products (from the boats to the engines for the airplanes) has very high environmental uncertainty and high information processing need. Applying Ashby’s Law (“Only variety can destroy variety”), we can suggest that *providing the environmental information for the purchasing process can help to reduce uncertainty*, i.e. risk. This is another benefit of the providing the capacity for the environmental information processing. If we look from the natural environmental performance and the uncertainty in the measuring of the environmental impact, then this can be also one of the necessary factors to be taken into account during the process selection. Hence, *the more difficult accounting process, where many factors which are not under control of the organization may influence on the overall impact, and the more significant impact is, the bigger need in the providing the information processing capacity*.

IPT is also applicable for the considerations that should be done when IPC is designed. It is related to **the purpose and main characteristics of the IS/IT solution**. The questions about ability to provide coordination and monitoring of the process, the level of linkage with other systems and IT solutions, ability to supply as horizontal as well as vertical communication, appropriateness of the information, i.e. is comprehended by respective user on various levels, and timeliness are essential for the deployment of the effective IT solution (Tushman & Nader, 1978). In order to evaluate these parameters VSM can be applicable: first for the analysis of the viability, or in other words effectiveness, of the existing solutions; secondly, it can help to identify the clear requirements for the sought self-organizing systems.

It is important to assess IPN and IPC analyzing the process where IS and IT solutions will be evaluated. Taking into account the uncertainties which define the IPN and characteristics of the IPC, IT provider will be able to design more effective IS. One of the suitable models for it and necessary variables are proposed by Bensaou & Venkatraman (1995). These parameters will be considered in the model for the evaluation of IT solutions. But we need to keep in mind that simple increase of the amount of the information processed will not make the overall performance of the process or organization better, therefore organization has to make a decision about importance of the specific data processing. This importance can be assessed according to the significance of the environmental impact and relevance.

The basic logic discussed above is illustrated by the Figure 3-1.

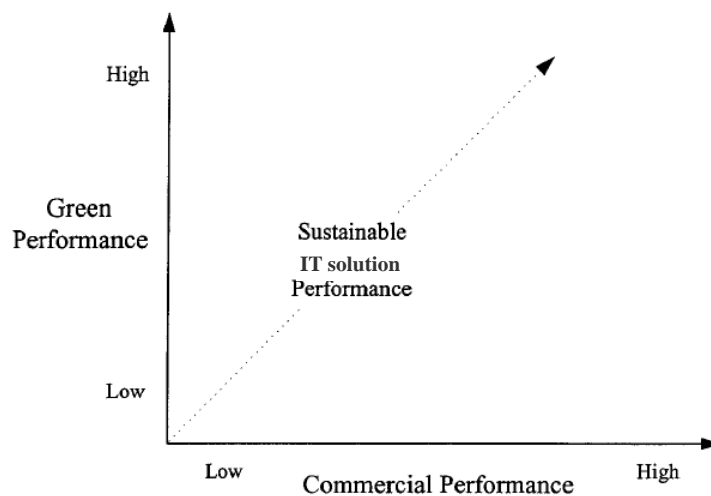
Figure 3-1 Information and uncertainties in the system



Scientific theories are used in this case as the proof of that IS/IT deployment for the control of the environmental aspects (data) is essential prerequisite for the better performance of inter-organizational coordination.

To conclude the discussion, the theory can be also applied for the further evaluation of the IT solutions, where “green” performance and commercial performance should be analyzed in the conjunction. For this purpose, the methodology proposed by Lewis & Stewart (2003) can be adopted (see Figure 3-2). Though, it is outside of the scope of the current paper.

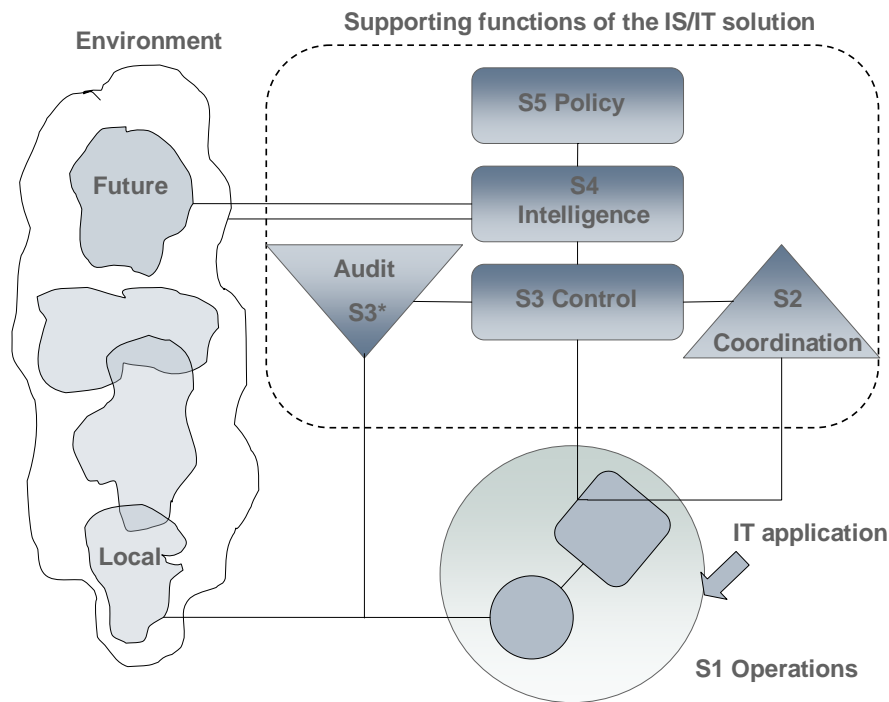
Figure 3-2 The measurement of Sustainable Performance of the IT solution. Adopted from Lewis & Stewart (2003)



3.4 Analytical framework for the analysis of the collected data

As it has been mentioned in the previous section, it could be helpful to use Beer’s Viable System Model for the evaluation of the existing IS/IT solutions on the subject of their viability, i.e. to provide diagnosis of the System as such and to identify the deficiencies and missing elements in the System. The VSM is depicted in the Figure 3-3, where some of the System’s functions are related to the conditions of research.

Figure 3-3 Viable System Model as the analytical framework



Therefore, the collected information about IS/IT solutions used for the supplier evaluation, logistics and business traveling will be scrutinized by means of this framework. The IS/IT solutions are viewed as the Systems as such, which operate in the specific environment, e.g. purchasing process and all organization, Volvo Group. IT application used for running of the process fulfils the role of the S1 Operations; other systems (S2, S3, S4, and S5) are supporting functions, which should be in place as well in order to satisfy the conditions for the self-organizing, effective and sustaining IS. Roles and functions of these systems are briefly described in the Section 3.1.2. Besides the analysis of the main systems’ functions, the overall viability, requisite variety, recursion and existence of the internal model and double-loop learning will be reviewed (see Lewis, 1997). Hence, as a result of the analysis, the basic parameters of the effective IS, from the environmental managements viewpoint, will be summarized and tested on the studied IS/IT solutions.

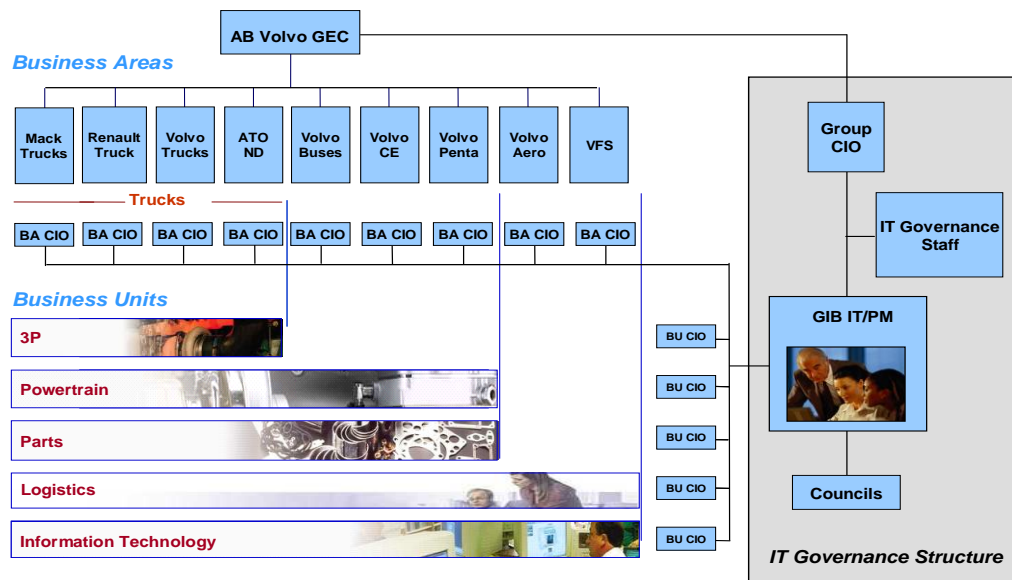
4 Presentation of Volvo Information Technology

This chapter of the thesis aims to provide an understanding of the studied organization and its interaction with IT and natural environment. The same Context Framework is used for the information collection as for the literature review. Basically, some of the notions from conclusions made in the Chapter 2 will be verified or supported with practical experience in the studied organization. The main data sources for this section are personal interviews corporate intranet, internal documents and other publications about AB Volvo and Volvo IT in particular.

4.1 The IT support of the Organization: Volvo IT “Let’s make sure”

Volvo Information Technology (Volvo IT) as such was founded in 1998. This decision has been taken by Volvo Group in order to secure the IT skills before Volvo Cars Corporation (VCC) has been acquired by Ford. This strategic move has combined scattered IT departments on the different sites and VolvoData, Volvo Group’s subsidiary set up back in 1967. Since then Volvo IT has experienced drastic growth during this time and has become truly Global company. Number of employees increased from 2500 to almost 7000 during years 2000 - 2008 in more than 35 locations around the World. Volvo IT is primary IT provider of Volvo Group, which also includes Mack (USA), Renault Truck (France) and Nissan Diesel (Japan). Besides this, VCC is one of the major external clients. Among other external customers are BMW, Scania, SCA, Nestle, Nobel Biocare etc. (Volvo Group, 2008a).

Figure 4-1 Volvo Group Structure

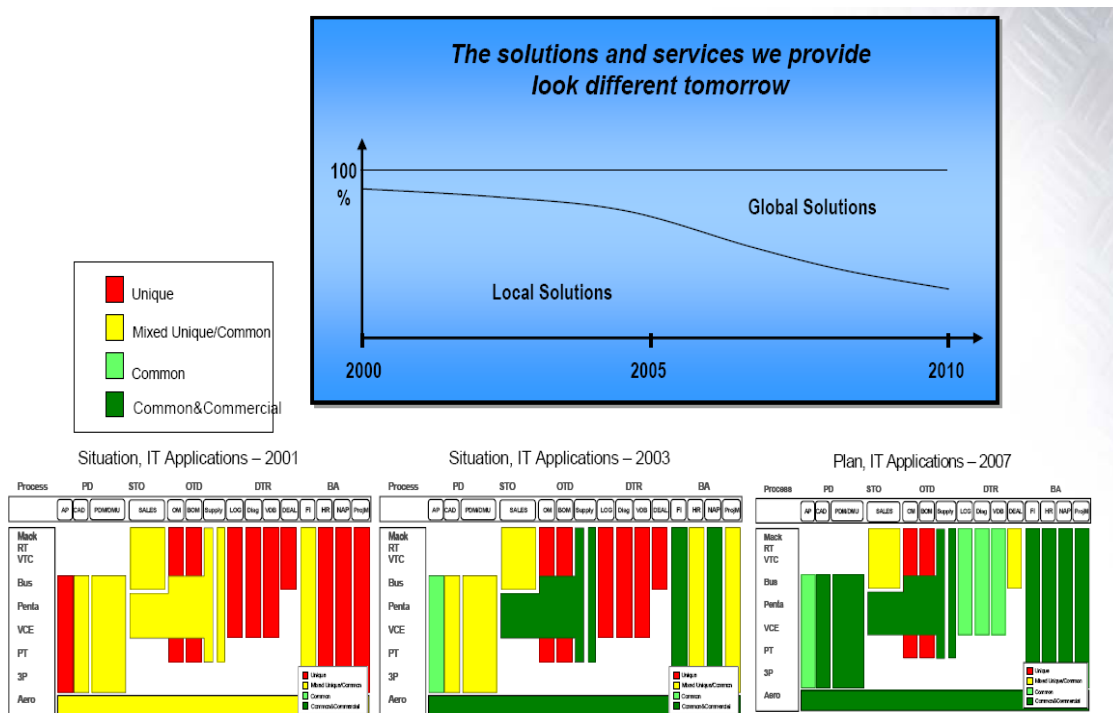


Volvo IT provides business solutions and services for the various processes and that are grouped according to the main value adding global processes (Product development (PD), Order to Delivery (OtD), Sales to Order (StO) and Delivery to Repurchase (DtR)) including business administration and IT infrastructure (see Figure 4-1). However, how it was emphasized on Volvo IT Europe Executive meeting in July 2008, the primary attention is on

the strategy course towards being more Business Solution provider rather than IT service provider (Volvo Group, 2008a). This strategy sounds inline with one of the Volvo IT’s mottoes “We create business value through IT”. Therefore it is very important for the company to provide not only necessary infrastructure but also to help customers to differentiate themselves on the market and support in on the way to the competitive advantage. Though, it is not very complicated task for Volvo IT since they always worked hand-in-hand with manufacturing and financial services of Volvo Group. This collaboration lasts already over 40 years. In comparison with other IT commercial companies, Volvo IT strives to help to the customers to develop their business and bring down IT costs at he same time

Acquisitions of the Mack and Renault Truck fostered the transition from the unique and customized solutions to the common and commercial. Basically all these 10 years were lead under the sign of globalization and integration: from e-mail services to such big systems like Global Dealer System or Global Purchasing System (see Figure 4-2). Integration of the information systems in different business areas and business units was a tool of total business integration which allowed cutting production costs and achieving economy of scales. Besides this, Volvo IT plays essential role in the moving towards product-service systems within Volvo Group. Their diagnostics and telematics solutions constitute the crucial and rapidly developing “service strategy” direction (Carlander, 2008).

Figure 4-2 Volvo IT is moving towards Global solutions



Source: (Volvo Group, 2008a)

As a part of the integration process, the IS-GDP method was launched on March 15, 2007. IS-GDP stands for “Information System Global Development Process”. The purpose of this method is to give a common framework for the development of projects related to the IS/IT. It provides the decision-making support for the steering committees from the change request or idea to the deployment and follow-up. It contains 4 key areas: business objectives management, solution management, business change management and project control.

However not all projects go through IS-GDP process. Only major projects which require more than 400 man-hours are eligible for the use of this method (Volvo Group, 2008a). Currently Volvo IT is working on the development of criteria for each gate, which would allow considering environmental issues on all phases of an IS/IT project (Holmqvist, 2008).

4.2 Environmental awareness of the IT provider: where Volvo IT stands?

First of all it is important to mention the environmental work that is going on in Volvo IT itself. Since IT providers have been considered as a “clean” industry till the recent time, the environmental awareness was not really on the agenda before 2007. The main concerns were quality of the service and, certainly, security. Even though the importance of the Volvo Group core values “Quality, Safety and Environmental care” is emphasized always. The significant role in the “push” of Volvo IT towards environmental care has been played by one of the biggest external customers – Volvo Cars Corporation, which has a strong policy for the “green” supply chain, where 100% of the suppliers should be certified according to the ISO 14001. Nowadays 2 production sites, purchasing department and data centers have gone through certification process already. However, Volvo IT doesn’t stop on that and plans to cover 50% of the sites where 95% of employees work till 2010 (Wemme, 2008).

Given that the environmental management systems (EMS) are still rather young, it was difficult to estimate the overall improvement of environmental performance. Mainly it is because of lack of the data before and after the implementation of EMS which would allow comparison. On the other hand, the “environmental” work has been done far before the certification process. The energy and efficiency management of the data centers were the key areas of the improvement. However, the consolidation and virtualization activities have been driven by costs reductions, and till very recent time, energy issues haven’t been considered as “environmental” in Volvo IT. Hence, when the work with environmental systems started, most of the necessary and possible actions in the field of energy efficiency of the datacenters have been done already. The cooling systems went through the major modernizations, there are the targets for further virtualization of the servers, the take-back system for the old hardware is in place and the particular attention has been paid to the packaging of the equipment etc. The requirements to the suppliers are another important aspect of the environmental work in Volvo IT. It is related to the fact that all IT equipment for Volvo Group is purchased by the respective departments of Volvo IT. It imposes great responsibility for the impacts in the supply chain. The main requirement is the existence of the certified EMS according to ISO 14001. However, other environmental aspects like energy consumption or type of the materials used are not included.

Certainly there are some other issues that were identified as rather important and not taken into account. In most of the cases they are related to the internal “office” operations, which are relatively big in the case of IT provider because of the type of the product and services they produce. One of them is the environmental education and awareness of employees. It has been noticed that the responsibility for all environmental work is on the environmental coordinator and manager while the rest of employees are not involved in it. However, this aspect has been emphasized by the management and there is on-going work related to the reduction of the resources consumption related to the printing (Richert, 2008).

4.3 Integration of the IT infrastructure for environmental care: what Volvo IT does about it?

Despite of some lack of the attention to the operational activities, the potential of IT as a tool for the reduction of environmental impacts, as well as enormous possibilities for the support of the environmental activities in such big and global auto manufacturer as AB Volvo, are recognized. First of all, Volvo IT perceives Information and Communication Technology (ICT) applications as the promising tools which can help to reduce environmental impacts of the user. This movement has been driven by the Volvo IT Innovation Centre and its director, Magnus Holmqvist in particular. The communication of the ongoing activities has been done by mean of the Volvo IT's magazine, *Use IT* (Volvo IT, 2007), through "Green IT workshop" in May 2008 as well as participating in the various seminars. Having very close collaboration with their customers, it was rather natural to develop solutions which would improve efficiency of the processes as well as of the products. Thus, the main examples are solutions for the reduction of the fuel consumption, routes optimization, and systems for more efficient move of the packaging. The significant focus is made on the promotion of the virtual conferencing and its integration in every day activity of the Volvo Group. It especially becoming more and more important due to acquisitions made during last few years.

The overview of the ICT tools provided by Volvo IT and their positive environmental impacts is presented in Appendix VI. In order to track the performance of these IT solutions, Volvo IT is developing *Green IT index*, which represents a set of key performance indicators for the processes where solutions are used. This also should help to communicate the achievements on the different levels of the companies and to the customers. The experience of different business units shows that they already could attain significant environmental benefits from application of IT. Volvo Parts uses IT systems for the optimization of the stock-keeping and service solutions to prevent unplanned stoppages. While Volvo 3P focuses on the virtual tests of the products not only to reduce lead times in projects, but also to save big amount of resources to produce and to test prototypes. Besides this, virtual meetings are becoming more and more spread in all AB Volvo. The acquisition of WirelessCars opens great opportunities for the reducing environmental impact on the use phase of the vehicles using telematics (Volvo IT, 2007).

In order to assess the situation with the integration of the environmental management and Information System, survey of the environmental coordinators and managers throughout AB Volvo has been conducted. Certainly it's difficult to make the reliable conclusions from such small sample, but since the aim of the survey was to analyze the trend and general situation the results have been found as quite useful. First of all looking at the results (Appendix V), the following conclusions can be drawn:

- Necessary environmental data is quite difficult to collect and the exact sources of such information are not specified
- Majority of the information is accessed from the processes itself and facility manager. However, only 1 responded mentioned that information is available in the IT application used for the process. Thus, we can make a conclusion that data collection is not automated enough and there is room for the improvement in this area.
- KPIs are used in some cases as the sources of environmental data that is a good approach for the integration of the environmental issues in the core business process. It can help to reduce time and costs on the collection of the additional information from the processes and would help to achieve higher rate of the involvement of the

various employees. Therefore it would be beneficial for the organization to develop this kind of KPIs

- The standardization and unification of the documents handling in AB Volvo is not really apparent. Different approaches to the environmental management can make overall reporting system and data aggregation quite difficult. This actually has found also the reflection in how annual sustainability report on the Group's level is compiled. For example the last report from 2007 was heavily based on the information provided by Volvo Trucks.
- Internal communicating tools like intranet or teamplace are used in the most of the cases. Therefore, it is very important to keep updated and complete information on these resources. These tools are also used to get acquainted with the activities of other BA/BU.
- Unfortunately, e-learning tools are rarely used for the environmental education of employees. Taking into account the global structure of the company, there is a high need in the developing such tools. Especially if there are already successful cases of e-learning courses in AB Volvo but for other purposes (e.g. AWARE (security), TimeWellSpent (use of LiveMeeting), Travel on-line (about travel booking system etc.)

5 Support of the environmental work in the purchasing process by IS/IT solutions

This Part of the thesis represents the essential stage of the research work and includes basic descriptions of the focus area: purchasing process. The description follows the conceptual framework described in the section 1.4. The third type of the interactions “Integration of organization, IT and environment” is covered by section 5.4, where the IS/IT solutions are reviewed from the environmental management support viewpoint. In general, chapter 5 is “as-is” description of the situation in the purchasing. Company’s intranet, personal interviews and other documents provided by interviewees are main sources of the data.

5.1 Purchasing in Volvo Group as the focus area

Purchasing process in Volvo Group is one of the core stages in the manufacturing and service providing. It represents basically the link between 2 global processes: Product Development and Order to Delivery, but it is also the connection to the numerous suppliers. Main procurement is made by specific business units which support the business areas (see Figure 4-1): Volvo 3P, Volvo Powertrain, Volvo Logistics and Volvo Information Technology. These business units are grouped according to the functions where automotive and non-automotive purchasing (NAP) are the major areas distinguished in Volvo Group. Concerning the number of suppliers, only NAP area accounts for about 22300 suppliers (June 2008) (Volvo Group, 2008a). However new acquisitions made AB Volvo even more global than it was before. It opened new markets and gave access to the new suppliers. Therefore purchasing in Volvo Group pursues the goal of “Global-Local industrial footprint”, where purchasing departments striving to reduce the amount of supplier choosing the multinational and reliable suppliers. This also should solve the problem of the distance between manufacturer and supplier since they still will be located in one geographical area. This approach has been chosen to reduce the risks and costs related to the supply chain management.

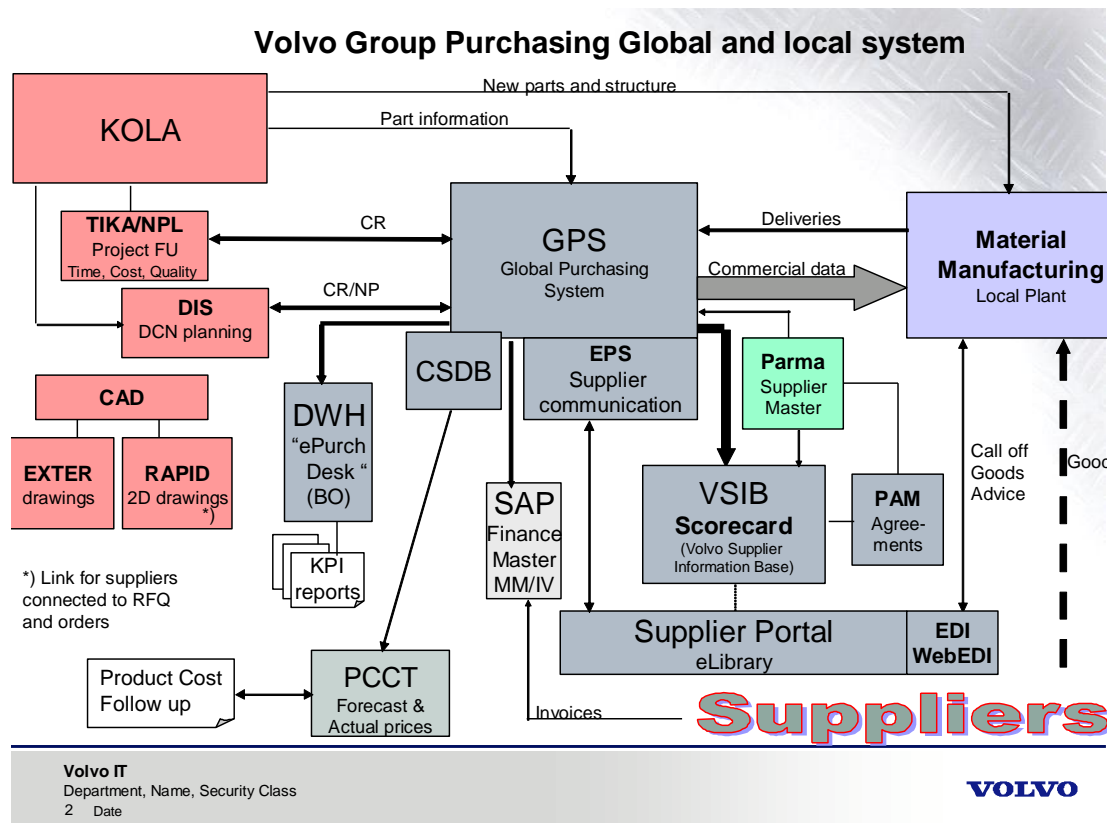
Global Purchasing Process consists of 3 major sub-processes: **sourcing** (defining the needs, total cost analysis, new suppliers search), **purchasing** itself (supplier relations, negotiation strategy, agreements & offers), **order management** (order handling, contract administration, invoice handling). The process of purchasing in its turn is divided on the following sub-process: RFI (request for information), RFP (request for proposal), RFQ (request for quote) (Christensson, 2008).

5.2 Information System that supports Purchasing in Volvo Group

Global Purchasing System (GPS) is the core IT tool which serves as the operational system for all process of purchasing from the sourcing of the supplier to the requests for the proposals. This system is connected with other solutions which are used in the product development processes (e.g. KOLA – Product Data Management System), in the manufacturing, for the supplier communication (e.g. ePS (electronic purchasing system)) etc. (see Figure 5-2).

Volvo Supplier Information Base (VSIB) is another application which is integrated with GPS and represents the supplier scorecard. This base stores and presents all results of any evaluations in the unified way, i.e. applying developed score system in compliance with Supplier Evaluation Model (SEM). This data helps to benchmark different suppliers and check their performance throughout a number of years. It also contains the information about the state of the ISO 14001 certification as well as results of evaluation of the logistics and environment.

Figure 5-1 Volvo Group Purchasing Global and local System



Source: Volvo IT

Concerning non-automotive purchasing, there is other system in place: *VeSa* (Volvo Group e-sourcing application). This application covers the same main steps in the purchasing processes as in the case of the automotive purchasing. *VeSa* is basically a communication tool with suppliers where all relevant documents are stored and exchanged between parties. However, *VeSa* is developed by external company and not by Volvo IT. Thus, all decisions about necessary changes should be made by the manager of the purchasing department where application is used.

ePurchasing desk is the tool which is connected to the GPS and represents the datawarehousing and reporting solution. A number of different KPIs are provided by this system to the different purchasing organizations within Volvo: MCL Real Effect actual & forecast; % of spend with valid purchasing strategies; Supplier counting; Payment terms; PPM / QPM; Number & % of ISO certified suppliers; % of spend with valid purchase agreement (Violin).

GPS, VSIB and *VeSa* are all connected to the common Volvo suppliers' and customer's register – *PARMA* (PARTner MASTER). It was launched in 1998 and allows having complete picture about the total business with any of the partners.

5.3 Purchasing in Volvo Group and environment

Considering the strategic position of the purchasing process in the company we can say that it can have a significant influence on the environmental impact throughout whole value chain. This importance is recognized by Volvo Group as well. This enterprise was basically one of the first companies in Sweden which started evaluation of suppliers from the environmental

perspective (Mårtensson, 2008). The Volvo Black and Grey lists were the principal tools for the consideration of toxic materials in the purchased products. It still lies in the base of the procedure for the materials selection in product development process as well as for the assessment of the supplied goods. The specific supplier portal provides all necessary documentation concerning requirements and policies of Volvo Group. The holistic life cycle perspective is chosen as the base for the examination of the supply network.

The issues regarding life-cycle performance of the purchased goods (environmental product declarations), eco-labeling, some specific details of the environmental management (e.g. action plans, reports about non-conformities, environmental targets), location of the suppliers and control of other tiers in the supply chain are also addressed in the environmental policy and Key Elements Procedure 5 “Environment” (Volvo Group, 2006). It includes the guidelines for the self evaluation of a supplier (checklists), as well as a number verification activities (e.g. SEM (Supplier Evaluation Model): short and extended versions, certification of the suppliers etc) performed and registered by the respective people in Volvo Group. These requirements are common for all purchasing departments in BA/BU of Volvo Group.

In general, if we look at the way how environmental aspects are embedded in the supply chain, product and process approach can be marked out. Though, in most of the cases, the aspect of the materials selection is not in the responsibilities of the purchasing but rather of the product development (design) process itself. The product approach is quite extensively used and managed during last few decades.

The process approach is reflected in the assessment of the suppliers’ activity concerning the environmental management. Currently, the main environmental focus is made on the number of the suppliers certified according to the ISO 14001 (100% certified suppliers - is one of the environmental targets of Volvo Group). Therefore this index is included in KPIs set for each BA/BU. This indicator is also stopping parameter. This means that supplier won’t be approved in the case of the absence of the EMS. In addition to this all interviewed purchasing departments are certified according to the ISO 14001. They conduct environmental training of the buyers on the regular basis. Some process management aspects such as business travel and resources consumption start coming on the agenda of the management.

Code of Conduct also covers the environmental activity of the purchasing and partners. It is a Volvo’s critical policy which should be followed by everyone and consists of 13 principles in the areas of business practices, environmental principles, human rights and workplace practice. Resource efficiency, precautionary principle and environmental performance are among environmental principles (Volvo Group, 2003).

5.3.1 Environmental aspects in the Purchasing: mapping focus areas

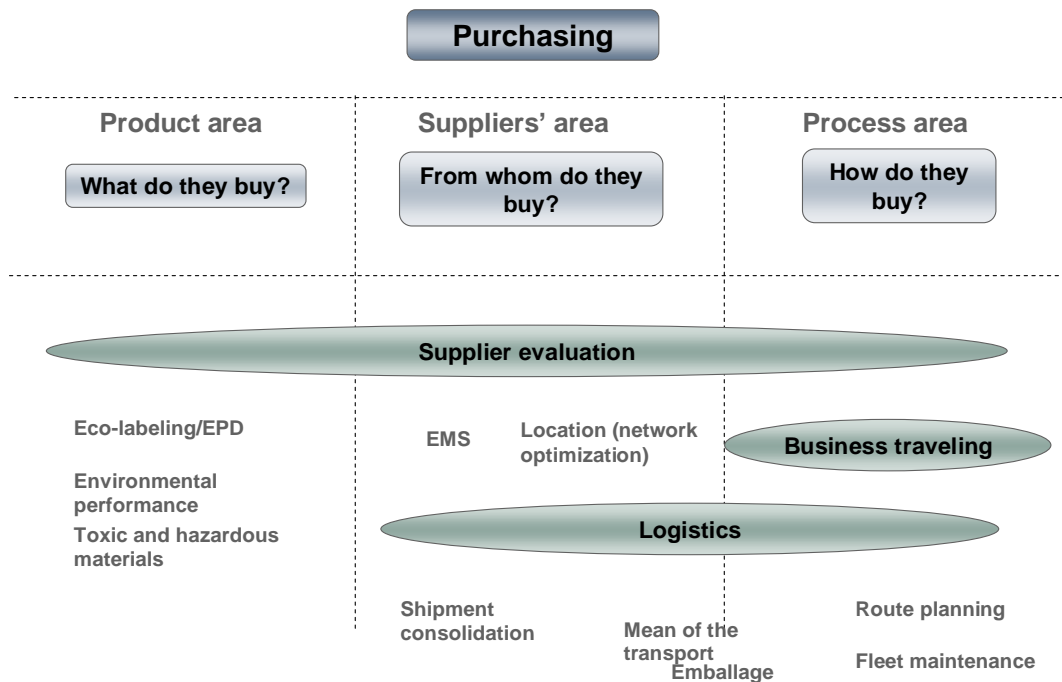
In order to proceed with the evaluation of IT solutions for purchasing process it is important to define clearly what are the environmental aspects in the purchasing process. Thus it will be possible to make out the possible measures necessary to reduce the impacts related to identified aspects as well as the opportunities for the IT solutions to assist in it. Assessing a purchasing process the 3 principal questions, which actually cover main activities in the process, can be taken into account: 1. What do we buy? 2. From whom do we buy? 3. How do we buy?

Figure 5-3 illustrates the relation of purchasing process areas (Product, Supplier, Process Management) with main environmental aspects. As we can see, the *supplier evaluation* is one of the most important purchasing aspects and covers all process areas and includes as well as

product as process focus. *Logistics* is also essential part of the supply. It may have quite significant environmental impact, especially considering global nature of the company. Logistics requires a number of decisions to be made such as what kind of transport to choose, how to provide the optimized route plan or how to pack and consolidate goods for the further transportation and so on. *Business traveling* is another aspect of the purchasing process with rather big environmental impact since the suppliers are located around the World and most of them require physical meetings for the evaluations/audits, conducting of negotiations and other orders handling issues. Certainly the described environmental aspects don't represent complete picture, but only give the examples of the possible areas for the attention. This approach provides the basis for the further IT solutions selection, i.e. what IT solutions can bring environmental benefits to the process and what can be done for their improvement. In the next section we will look into specific cases in Volvo Group, which describe the situation in purchasing process, as well as give brief overview of some of particular IT solutions used to manage the process.

However, it is important to point out that even though the environmental aspects (supplier evaluation, logistics and business traveling) fall in the current work under purchasing, the real case of Volvo Group looks slightly different from the organizational viewpoint. If we look at the figure presented in the Appendix VI, where all business areas (BA) and business units (BU) are depicted, various BUs are responsible for the each of the "aspects". For instance, Volvo Logistics performs logistics services, while Volvo 3P and Volvo Powertrain are responsible for the automotive purchasing. However, approach described above helps to point out on the areas where purchasing has an influence and responsibilities, covering the possible actions that can have an environmental impact.

Figure 5-2 Framework for the assessment of the purchasing process



5.4 Does existing information system help to manage environmental aspects?

5.4.1 Supplier evaluation

5.4.1.1 Automotive purchasing

Main information about automotive purchasing has been collected by means of the personal interviews with representatives from purchasing departments from Volvo 3P and Volvo Powertrain. These 2 business units are major buyers for automotive manufacturing in Volvo Group. As it has been said in previous section, purchasing departments are quite proactive concerning environmental issues. However, in most of the cases, environmental work doesn't proceed further than checking suppliers on the subject of the environmental management system certification and presence of the hazardous and toxic chemicals in the products. Though, it does not show that studied departments did not consider more detailed aspects of the supply chain management or they are resistant to such procedures. One of the main barriers they encounter is a lack of the resources to carry out necessary actions for the supplier evaluation. Basically it's related to the increased amount of the data which should be collected, tracked and processed on the regular basis.

Supplier evaluation data is managed by means of a number of different IT solutions. VSIB is one of the most comprehensive evaluation database and it contains following information: volume value information; aggregated supplier structure; buyer information; certifications; reports capabilities; quality/inspection information; supplier scorecard (3P/VPT); financial scorecard (3P). The Supplier Scorecard represents the particular interests from the perspective of the assessment of the environmental performance of the supplier and displays:

- Data about the Supplier Performance: results and figures (ppm, QPM, Delivery precision)
- Data about the Supplier Profile: information and status (Suppliers spends, audits, SEM, certification...)
- Trend of the performances
- Performances targets (ppm, QPM, Delivery precision)
- Alarm in certain cases, when the results are worse than the targets
- The date of the latest update for each of the information & data displayed

Some of the suppliers have access to the VSIB where they can check their profiles or update certain information. Supplier evaluation is performed on the Request for Information phase.

It has been recognized by all purchasing departments that one of the main problems they encounter during the process of the KPI monitoring is the tracking of the validity of certificates. In our case, it is certification according to the ISO 14001 standard. There are many suppliers with certificates which are expired already. Thus, responsible buyer has to contact the supplier and update this information. Besides this, it is quite difficult to identify expired certificates, so the purchasing departments are checking up to 100 of the largest suppliers on the regular basis.

As for the environmental performance in the frame of the supplier evaluation model (SEM), it is done by mean of the self-assessment according to the checklist in the Key Elements Procedure. It consists of 3 parts: A. questions related to the environmental situation of the company (e.g. certificates, requirements to their suppliers, improvement plan etc.); B. questions related to the products and services (i.e. compliance with “black” and “grey” lists); C. additional information. All answers are scored. In order to be approved as a supplier the score should be more than 60% (Christensson, 2008). However, the interesting fact is that the supplier can get only maximum 3 points (out of 99 possible points) having certified system and filling more than 90% of the environmental self-assessment list (e.g. quality has 18 point and product development – up to 15) (Volvo Group, 2008b). From the observation of a number of the supplier scorecards, any of them has not had results or passed the environmental evaluation.

Even though, the environment is one of the core values, it was difficult to observe that the actual environmental work takes place in the supplier evaluation process. The identified barriers are:

1. **Collection of the information is time consuming** (e.g. self-assessment list is a PDF file which has to be sent to the supplier; after the completing it, they send it back to the buyer who has to review and enter manually the score in the SEM and VSIB)
2. **There is no incentive for the supplier to fill the self-assessment list** since it doesn't play essential role for the approval process.

5.4.1.2 Non-automotive purchasing

Non-automotive purchasing (NAP) includes all purchasing which is not related to the process of automotive manufacturing as such. Hence, purchasing performed by Volvo IT and Volvo Logistics and Global Business Service is the part of NAP. These business units provide all purchasing service in the information technology, logistics and business travels fields. Other types of NAP are not included in the research scope.

The same procedure “Key Elements 5 “Environmental requirements” is applied concerning suppliers evaluation, and KPI related to the number of the certified supplier is also used in NAP. Thus, the same problems and barriers are met in non-automotive purchasing. However, in the case of Volvo IT, the questionnaire about environmental performance is used on the last stage of the supplier evaluation, when there are only a few candidates left and they are almost approved technically.

5.4.2 Logistics

Volvo Logistics Corporation (VLC) is the business unit which supplies all logistics services (inbound, outbound, emballage) to all business areas and business units within Volvo Group (see Figure 4-1). Besides this, they have also a number of the external clients. Considering the information obtained during personal interviews, the environmental awareness in the company is quite high. The pressure from the stakeholders plays essential role for more active environmental work. Most of the customers, including Volvo Group, stress the importance of the reduction of the greenhouse gases emissions. Moreover, the management also recognized significant business benefits from the environmental work. In the most of the cases it is related to the cost reductions derived from the improved efficiency.

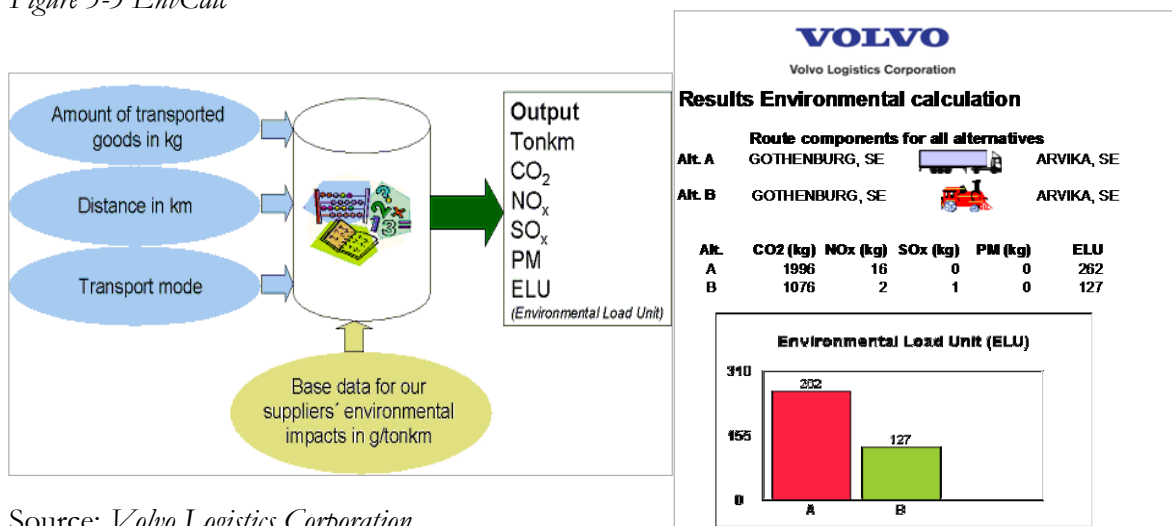
There is the separate Core Values department which is responsible for the management and accounting of the performance concerning quality, environmental and safety issues. The important aspect is that the location of the supplier is defined by the buyer in the automotive or NAP purchasing, so the main task of the logistics is to deliver goods in timely fashion and with lower costs. Since VLC doesn't operate the own fleet, main activities are based on the selection of the carriers, planning and optimization of routes. Basically VLC is the purchasing, design, consultancy and cost control company, and represent the important connection between customers and carriers, operating the big amount of the information concerning the mentioned above activities.

There are a number of the solutions which are used for the optimization and decision-making, e.g. VLC++ network, Proxio Optimizer, Volvo Emballage management System. Besides this, there is also software EnvCalc that calculates GHG emissions from the various ways of the transportation. Therefore the brief overview of some of these applications is given in order to proceed with further evaluation.

EnvCalc

It is a pre-assessment tool which is optionally used for the support in decision-making concerning the route and carrier for all new or altered logistics setups. EnvCalc was introduced in 2005 and enables calculations CO₂-, NO_x-, SO_x-, and particle matter (PM). The emissions are also weighted according to the Environmental Priority Strategies (EPS) method (Steen, 1999). Results are presented to the user and they form a basis for the further decisions. This tool is internal and used by the Logistic Developers, Account Managers and Purchasers. In order to receive authorization to use EnvCalc, employees have to pass a 3 hours training, where basic information about environment, impact of the transport on the environment and life cycle assessment are given.

Figure 5-3 EnvCalc



Source: Volvo Logistics Corporation

The tool is required to use in the cases when new logistics solution has to be developed or some changes has to be made. It results in rather low rate of the environmental calculations made, for example it was used 54 times in year 2007. Certainly company is working on the increase of the amount of done estimations and also puts targets. However, there are some possible barriers for the application of EnvCalc: employees forget to use; low awareness;

assume that it takes too much time; assume that customer won't be interested in the environmental evaluation since the price is more important (Carlsson, 2008).

Proxio Optimizer

Proxio Optimizer is a new software application developed by Proxio AB as a result of the collaboration with VLC. It is a business driven solution and a simulation tool which assists buyers of transport services to enhance the efficiency of the transport and logistics services. In addition to the significant costs reduction, this application also helps to cut carbon emissions. Besides complex logistics calculations where such parameters as volume variations, transportation needs, tariffs, loading mix, detailed costs and structure analysis, schedules, best routes choices are taken into account, Proxio Optimizer can also calculate and optimize the emissions of carbon dioxide, evaluating different transport services and work is under way to further improve the efficiency of the software with regards to the environmental area (Volvo Group, 2008a). It allows making the necessary calculations in a few days (otherwise it would be done manually with Excel spreadsheets during a few months). This software is able also to present the graphical overview with maps. Other important feature is that Proxio Optimizer can work as a stand alone as well as an integrated into existing systems solution (Proxio AB, 2008). Volvo Group has recognized strategic importance of such application for the business and invested in Proxio AB together with KTH Chalmers Capital (Volvo Group, 2008a).

Proxio Optimizer has around 10 active users in VLC. Currently it assesses the logistics scenarios from the cost perspective providing suggestions for the best cost wise transport solution and is run for the big projects. However, the running of this application encounters some difficulties related to the availability of the high quality data. For example, there are 3 logistics applications which are used in the European region since almost 70s and all of them have different design. Therefore, in order to proceed with optimization there is a need to collect, clear and enter manually all necessary transport information which includes amounts, destinations, dates etc. Nowadays, VLC is working on the consolidation of those applications in one single global system for the inbound logistics - ATLAS. This system will handle all logistics information besides costs. In this case the use of the Proxio Optimizer will be facilitated in the large extend. Most probably it will be used in the future for the inbound and emballage transport solutions. Proxio AB is working now on the environmental evaluation matrix where besides costs optimization, the environmental impact will be taken into account. EnvCalc is a possible application which can be used as a basis for the environmental evaluation in Proxio (Erkfeldt, 2008).

5.4.3 Business traveling

Business traveling constitutes the essential part of the work in the purchasing departments. Especially it is relevant in the case of Global and multinational company with branches and production sites about the World. For example, according to the data obtained about Volvo IT, the number of intercontinental trips increased on about 15 % in 2007 in comparison with 2006. It caused the significant costs increase in the company during a last few years. As a result Volvo Group introduces and supports a number of activities which suppose to reduce travel costs. First of all, there is a limited budget for the departments with targets for the costs reductions. Virtual meetings tools like NetMeeting and LiveMeeting are also extensively promoted within company. The equipment for the videoconferencing has been purchased. The implementation of the on-line booking system is a way to track and reduce costs as well.

Besides urgency of the high travel expenses, the environmental impact from business traveling is coming on the agenda of some BA/BUs:

- Engineering department in Volvo 3P launched GHG emissions accounting system. The spreadsheets are used for the calculations and all data is entered manually. It has been confirmed that the accounting of the business travel emissions is very time consuming and complicated process. They also assign the limits and targets for each employee (Larsson, 2008)
- Core Values department in Volvo Logistics, for example, is discussing to implement the attachment to the Group's travel policy where environmental aspect will be included (Carlsson, 2008)
- Purchasing department in Volvo Powertrain considered the business travel accounting as a mean to control their environmental impact (Christensson, 2008)
- The Global Business Service (GBS), the unit which is responsible for the business traveling and represents the part of the non-automotive purchasing at the same time, also plan to update travel policy for Volvo Group in their turn. Moreover they collect data about business travel emissions of all BA/BUs on the regular basis with statistics on various destinations (Skoglund, 2008). However, the data in GBS is aggregated according to the BA/BU performance that makes difficult to relate the individual performance to the separate departments. In addition to this, most of the interviewed BA/BUs didn't know about the possibility to obtain CO2 data about business traveling.

It was difficult to select a purchasing department and explore the traveling and related expenses in the specific case. Moreover, the business trips management occurs in the same way in all Volvo Group independently from the department or process. Therefore, the information system will be reviewed from the general perspective where *Travel On-line* is the core IT application.

In order to proceed with further assessment it is essential to get acquainted with the travel booking process on the example of Travel on-line tool. First of all, Travel on-line is web-based system developed by Amadeus, Global Distribution System founded by the leading airline companies. It is self-booking tool which is mandatory for use in the case of the preliminary specified destinations. The destinations vary from the country where system works (currently it is Sweden and USA, France will be the next country). This tool was first launched in Sweden, October 2006⁸ and used by most of the BA/BUs. Travel on-line allows getting the access to the lowest fares on air, hotels and rental cars and has increased value for travelers providing 24/7 service, instant confirmation of bookings, map and hotel details and Outlook calendar update. It also gives an opportunity for Volvo Group to assure higher security of the traveling employees being able to locate them in case of an emergency (Skoglund, 2008). Volvo IT has developed the traveler profile data base. It is owned and managed by AB Volvo. This data base is used for both off- and on-line reservations. So, the booking process can be described in the following way: traveler makes booking on Travel on-line (air flight, train, car, hotel), then all data goes to the traveler profile data base; the system sends notification to the responsible for the decision-making manager, i.e. budget holder; after approval information is sent to the Global Business Service where travel is scheduled through Outlook; after travel has occurred already and all information is submitted to the GBS, travel report is generated (see Figure 6-1). E-learning tool for the on-line booking has been developed too, where all aspects of the new booking process are described in detail.

⁸ Before all travel bookings were made via travel agency

6 Integrating Environmental Information in the Business Information System

This chapter aims to align theoretical consideration with practical experience obtained in the company. In order to facilitate the process of alignment, the practical data will be analyzed in accordance to the analytical framework, described in the section 3.4. This chapter also contains the recommendations for the IS derived from the analysis and the overview of the general framework of the evaluation process of the IS/IT solutions taking into account the environmental considerations. The Environmental Information System Evaluation Framework (EISEF) represents main outcome of the thesis and also the answer on the second research question, which concern the integration of the IS/IT solution in efficient and effective way. Section 6.4. gives some practical recommendations for the application of EISEF.

6.1 Viability of the IT solutions as the information systems

The overview of the solutions will be analyzed from the perspective of the environmental viability of the information systems which are used for the management of the certain processes. The Beer's Viable System Model (VSM) will be applied for the analysis of the environmental management systems following the methodology employed by Lewis (1997). This approach has been taken because it allows looking at any system from more holistic perspective; it underpins the organizational theories and provides explanations necessary for the diagnostics of the system. All three studied IS/IT solutions are discussed from the view of the VSM's principles applied for the ability to manage the environmental information: *autonomy and freedom; viability; operations* (System 1⁹) and *coordination* (System 2); *control* (System 3) and *auditing* (System 3*); *intelligence* (System 4) and *policy making* (System 5); *requisite variety; internal model and double-loop learning; recursion and cohesion*. Existence of these elements-principles is vital for the self-organizing and viable system, which functions in the most effective way. Thus, the information system that aims to improve environmental performance of the user should have these features in order to assure the effectiveness of the environmental measures, and to bring the desirable positive change in the organization. The sections are structured in a way where the explanation of the element from the viability point of view is given first in order to provide insight on how viable (sustainable) system should operate. The following part of the section gives the analysis of the observations from 3 areas in accordance to the features viable system must have. The summary Table 6-1 of the analysis provides an overview of all elements.

6.1.1 Operations (S1) and Coordination (S2)

The important feature of this area is that any of the viable systems have to be able to assure daily decision-making in the environmentally responsible way. These decisions should be made as autonomously as possible but within clear framework of the accountability. This framework is based in the coordination mechanisms inside the process and in the company as such. The authority for the taking actions, as well as the responsibility for the environmental performance should be diffused among the employees.

The core IT application fulfills the function of the Operation. From this point of view, the IT application as an essential part of IS/IT solution, has to be able to provide necessary data for the day-to-day decision making, related to the environmental impacts of the processes, where

⁹ A brief description of five systems –elements of the VSM is given in the section 2.1.2. the illustration of the model can be found in the Appendix II. The graphical view of the VSM functions is given in the section 3.4, where the analytical framework has been presented

this system operates. All 3 cases represent quite weak compliance with this principle. For example in the case of the supplier evaluation, the system doesn't support the following of the Key Elements 5 procedure for the environmental evaluation and is not able to make the necessary for decision-making data available. The coordination mechanism as "Key Performance Indicator (KPI) – certification of the supplier according to the ISO 14001" is not maintained as well. The similar situation is observed within the business traveling solution. There is no support for the "environmentally friendly" decision-making made by an individual traveler or even by the department or BA/BU, but also the coordination function like a policy or targets is lacking. EnvCalc could be a good example of the supporting IT application; however it doesn't assure the autonomous work of the buyer in their day-to-day actions since the calculations are made by the assigned person after request and is a stand alone application which is not integrated in the daily purchasing IT system. However if we look at the general enterprise architecture (see Figure 4-2), Volvo Group is moving towards more flexible, global and "involving" information systems. Existing systems are able to manage other important parameters of the processes such as quality or customer satisfaction and costs within clear coordination mechanisms.

6.1.2 Control (S3) and Auditing (S3*)

These elements provide verification and validation functions for the system. They ensure that organization's policies are effectively implemented. They "test, check, regulate and balance" to assure the stability of the system. Therefore, system should be able to provide as much as possible real time data in accordance to the coordination mechanisms and overall organization's policies to be able to supervise the operations. However, the control function should have a requisite variety to be effective. Audit function should be capable to carry out a spot check whenever it is required by the management.

Looking at our IS and results from the analysis in the previous section we can say that control and auditing functions are not in place in all cases, i.e. they are not able to control and verify the compliance with policies in real-time mode or whenever it is required (in case of audit). For example, in the case of the KPI, system is not able to satisfy the demand in the updated information about valid certificates and number of them, even though this KPI is one of the most important in the Volvo Group. It is not possible, as well, to generate the report about the state of the environmental evaluation of the suppliers, but this deficiency is probably related to the not sufficient coordination mechanism, where this evaluation has secondary importance in comparison with other criteria, like quality, if there is certified EMS. The similar situation is in the case of logistics. Since there is no strong policy or targets about their emission reductions they only track the improvements of the carriers' performance. The system is also not able to control the necessary criteria in real-time mode or at least in the relatively short time span. Most probably with deployment of the Proxio Optimizer and ATLAS it will be possible, but only if there are the clear policy and targets from the top management. In other words the purpose of the system is clearly defined. The business traveling system doesn't have control and audit functions either or we can say that these functions are not applicable. It is related to the lack of the coordination mechanisms, i.e. there is no policy for the improvement of the environmental performance in this area.

Thus, analyzing the systems from this perspective we can say that they almost don't have any control over the operations and their environmental performance. Certainly, the environmental issues are not as vital currently as a quality of the service and efficiency of the process. But there is quite clear link between all of them. Hence, in order to be able to maintain the systems on all levels, and especially on the higher levels, in the viable state, organization should possess higher variety than it is done by now. For example, the solution

for the web-based self-environmental evaluation of the suppliers would allow possessing much higher variety and also would give more control over the process.

The control and auditing functions are also very important to be considered when new solutions are developed. It's especially relevant if those IT solutions aim to substitute some physical operations or to improve efficiency. The lack of the real-time and up-to-request data doesn't allow to estimate the achieved improvements in the operations and to communicate them using the reliable data. This situation has been observed in the case of the Volvo Emballage Management System or Virtual Meetings for example. It is difficult to evaluate the improvements since there is no information about the baseline and there is no accessible data about the present situation. Therefore, the good solution would be to embed the measurement function as soon as the IT solution is deployed. It can be done through built-in monitoring or by mean of the indicators which would be easy to track using the available data.

The maintenance of the audit function is also very significant from the environmental management point of view. It can provide necessary information for the reporting data to the sustainability reports or in the case of the monitoring and audits of the EMS. This function should be able to generate the report upon the request from the interested party, e.g. report about individual or department GHG emissions from the business travel or number of the suppliers with certificates close to the expiration date. It will facilitate the work of the involved in system employees in the great extend.

6.1.3 Intelligence (S4) and Policy (S5)

Intelligence function is necessary to monitor the total environment were organization operates. It is able to predict the trends in the future. The policy in its turn reflects the purpose of the system, defining system's identity, sets directions for the devolvement of the guidelines for coordination and control functions, and is responsible for the long-term strategic planning.

It is difficult to analyze the information system from the perspective of intelligence and policy since these functions are more relevant for the organization as such. However, in order to assure the effective and efficient functioning of any IS the intelligence and policy functions, which guide the deployment of the system, should be present. Looking at the environment where system operates, we can assume that knowledge about the processes where these systems are deployed is crucial for the viability. In this case, a system will be able to adapt to the changing environment (e.g. new requirements from the customers, new technologies, changes in the legislation etc.) and be self-organizing.

Thus, IT provider, developing and maintaining the IS, has to have the intelligence unit in place. This unit will be responsible for the communication and collaboration with the customers. In addition to this, the unit should acquire the specific for the area knowledge. In the case of the relationships of the process or organization with the natural environment, there should be the expertise with certain expertise about the process and its impacts on the environment. Examining Volvo IT we can say that this intelligence function can be provided by the IS-GDP (Information System – Global Development Process). It assures the sufficient flow of the knowledge between developers and the customers, necessary for the effective development of the IT solutions. The function of the information exchange is performed by various steering committees. Management and Enhancement Control Model (MCM) has been created to maintain follow-up improvements of IT solutions. The environmental considerations are not put into practice as yet, but there is on-going work on the development of the guidelines for each decision gate.

6.1.4 Viability

The viability of the system is defined as ability for the self-organizing, and very close to the meaning of the sustainability in the environmental context. According to the Beer's Viable System Model, the system has to have certain 6 functions, which are discussed above, to be able to "survive" and to be effective.

Considering the arguments presented in the previous sections we can come to the conclusion that most of the studied information systems are not viable and can't support the environmental work within the organizations. There are obvious deficiencies in the S1, S2 and S3. Systems can't provide the real-time information neither for the decision-making in the operations nor for the control functions. In addition to this, there is lack of the coordination mechanism such as policies and targets. Therefore, there is no clear environmental purpose of the IS. The positive trend is observed in the S4. Hopefully with the support of the environmental expertise and specific procedure for the development and maintenance of the IT solution it will be possible to adapt the IS to the changing environment and imposed by it requirements.

6.1.5 Internal Model and Double-loop learning

It is a feature of the system to "learn" from the operations and to be able to adapt to the changes.

The studied information systems are quite rigid and difficult to change. However, Volvo Group and Volvo IT, in particular, are in the process of the re-organizing of the main processes and information systems respectively. There are ongoing activities for the improvement and updating of the IT solutions, like in the case of ATLAS in Volvo Logistics and Supply Chain Management solution in Volvo 3P. The reconsideration and re-assessment of some applications gives an opportunity to adapt them to the changing requirements. Double-loop learning is related in our case to the IS-GDP and MCM. But the desired move towards better environmental performance could be performed with additional intelligence about environmental issues in the processes where IS are deployed.

6.1.6 Requisite variety

The ability to control the environment where a system operates is characterized by the requisite variety, i.e. system has to possess the same or bigger variety in order to be able to control the uncertainties in the environment. According to Lewis (1997) the presence of the large amounts of the information within the system (e.g. to maintain internal control of the operations) and between the system and environment is crucial for the viability. However, taking into account the Information Processing Theory (IPT) and the concept of "fit", discussed in section 3.2, it is not efficient to strive to the as big amount of the information as possible. Therefore, IS has to provide the fit between information needs (IPN) and information processing capacity (IPC).

The information processing needs in the supply chain management were discussed partially in the Chapter 3 of this thesis. The process of the purchasing has the clear features of the process with high information processing needs (IPN). There is high task complexity, high task interdependence, high inter-unit task interdependence and high uncertainties in the environment (Tushman and Nadler (1978)). The presence of the high and uncertain risk, which is difficult to evaluate, is recognized also by the interviewees, involved in the supply chain management. It makes complicated the weighted evaluation of the suppliers and logistics solutions, considering externalities (e.g. risks related to the political situation, performance of the supplier, geographical positions of the supplier etc) (Erkfeldt, 2008). This uncertain risk includes also the risk related to the uncertainty of the environmental impact which is difficult to quantify in the case of the supplier evaluation or even logistics. As it was

mentioned in the section 3.3, providing of the environmental information would assist in the better control over the processes. For example, in the case of the business travel and expenses, the accounting of the business travel related emissions could help in achieving other goals through the better management and more effective identification of the causes of high and not necessary expenses. If we look at the automotive purchasing, “stricter” control of the environmental performance of the suppliers can help to reduce the risks which are difficult to assess.

Examining IPN from the perspective of the customer’s need in the information, driven by the compliance with company’s policy or other proactive environmental initiative, we can say that existing information systems don’t possess the necessary capacity to process the required information. The types of the information and situation in the studied cases were discussed in the sections 6.1.1 and 6.1.2. There are following examples where IPC doesn’t satisfy IPN:

- purchasing departments in Volvo Powertrain, in Volvo 3P and Volvo Logistics want to keep track of their business travel emissions, however there is the lack of the expertise and the process of the accounting is time consuming. This problem could be solved with IT solution re-designed for this purpose. Moreover, most probably other BA/BU will have demand for such information very soon
- collecting of the information about environmental performance of the suppliers is also seen as very resource consuming and difficult to perform, therefore the need for the information system which would help to collect, process and store the data about suppliers
- Volvo Logistics experiences the high pressure from the customers and other stakeholders to reduce their emissions related to the transportation of the goods. Certain actions have been taken such as building rail lines, selecting best performing carriers or taking environmental impact into account for the decision-making. It is still difficult to estimate the improvements because of the complexity of the transport operations and the scope. It would be possible if there are certain IT solutions in place which assist not only every day operations, but also would support the reporting activity and follow-ups for the continuous improvement.

However it is important to take into account the factors which define the IPC, where presence of the information system doesn’t solve all problems. IPC is influenced also by the combination of the coordination and control functions together with the organizational structure.

6.1.7 Recursion

Recursion is the feature of the systems, where each system contains other smaller systems, and all of them are the part of other system of higher hierarchy. The System Hierarchy differs from the used management hierarchy and related to the scope of activity, e.g. Corporation, Business and Operations. Every system has its own environment. There are 2 consequences observed from this concept: higher level of recursion is only viable if lower levels are viable and each level has to align its activities with next level (Lewis, 1997).

The pursuing of this concept is very important for the design of the business information system. The experience from the studied cases shows, that if information system architecture doesn’t foresee the integration with other systems in the process most probably the new system won’t work in the sufficient way. This situation has occurred with EnvCalc application in VLC operations. The absence of the alignment with core purchasing system leads to the

low rate of the use of the calculations in the decision-making process. From other side, Proxio Optimizer is an example where the system design provides the possibility of the integration with other systems, even though there is still the need for their deployment, i.e it can't function properly without input from other sub-systems. From the perspective of the existing System Hierarchy, the automotive purchasing system (Figure 5-2) partially reflects this concept. GPS is as a mother system includes VSIB, DWH, ePS and other systems. Therefore, the viability of GPS will depend on the viability of the sub-systems. The concept of the recursion has to be taken into account when the improvements or other changes are undertaken in other subsystems. Moreover, higher rate of the systems' integration and alignment make overall business information system less sensitive to the information overload, thus they have higher information processing capacity (Tushman and Nadler, 1978).

Table 6-1 The summary table of the analysis of IS/IT solutions according to the Viable System Model

	Supplier evaluation		Logistics	Business traveling
	automotive purchasing	non-automotive purchasing		
Operations and Coordinations				
support of the decision-making with necessary information	-	-	+	-
coordination mechanisms (framework for the accountability)	+	+	+	-
autonomous operations	-	-	-	+
Control and Auditing (ability to detect deviations from the norm)				
provide control functions	-	-	-	n/a
provide audit function	-	-	-	n/a
Intelligence and Policy (initiation of the corrective actions)				
support of the intelligence functions	+/-	+/-	+/-	+/-
presence of the policy	+/-	+/-	+/-	+/-
Viability	-	-	+/-	-
Internal Model and Double-loop learning				
ability to adapt the system according to the changing environment	+/-	+/-	+/-	+/-
Requisite variety				
variety in the environment where system operates (information processing need)	high	high	high	medium
possessed variety by the system (information processing capacity)	not sufficient	not sufficient	not sufficient	low
ability to manage relevant information in the reliable and real-time mode	-	-	-	-
Recursion				
system hierarchy	+	+/-	+/-	-
alignment of the activities with next levels	+	-	-	-

"+" - requirement is fulfilled

"-" - requirement is not fulfilled

"n/a" - not applicable

"+/-" - requirement is fulfilled partially

6.2 Possible improvements derived from the analysis part

6.2.1 Supplier evaluation

Considering the results of the analysis part and discussions during the interviews, including persons who are responsible or took participation in the development of the tools, the next suggestions for the improvement of information system for the supplier evaluation in automotive purchasing could be given:

1. Taking into account weak support by the operation and control functions (S1 and S3); there is the need for the up-to-date data according to the coordination mechanisms. Therefore, it would be beneficial to modify the Volvo Suppliers Information Base (VSIB) in a way when system will recognize the expiration date of the certificate and gives notification to the supplier and responsible buyer. It can be done also gradually with prior notification 3-6 months in advance.
2. The access to VSIB for the suppliers should be more regular and they should be able to update their own information. The questionnaire for the supplier evaluation should be web-based with automatized score calculation and connected to the VSIB. In addition to this, suppliers should be able to upload relevant documents which prove the consistency of the activities with provided information (e.g. copies of certificates, action plans, policy etc.). These measures can improve the situation with autonomous operations in the S1, will reduce the work-load of the buyers facilitating the decision-making and control, and will improve flexibility of the system, thus its ability to handle more information.
3. In order to improve work of the control and audit system, it would be favorable if a supplier who hasn't updated information in time would be temporarily blocked in the supplier search system (e.g. PARMA), so they won't receive the requests for proposal from Volvo Group. In this case the information system will show the ability to identify the deviations from the norm and initiate the changes, thus will demonstrate ability for the double-loop learning.

These measures are considered rather simple but they would significantly improve the work of the buyers; would allow tighten the environmental requirement in the supply chain; would provide more complete and updated information about suppliers' performance; would improve relationships in the supply chain and reduce the risks related to the reliability of the suppliers. In most of the cases, the positive outcomes are related to the increased variety possessed by the system. In addition to this, the company still should maintain the KPI concerning certification, but it's definitely not enough to rely only on this measure, especially if it is difficult to track the actual performance of the suppliers. One of the suggested indicators could be: % of suppliers who have done complete/and partial self-assessment.

As for the purchasing system and supplier evaluation for the non-automotive purchasing, the situation is similar to the previous case. After discussion with the technical expert who is knowledgeable about VeSa, following additional to the mentioned in the previous section suggestions can be given:

1. Perform evaluation on the Request for Information (RFI) phase as it is done in automotive purchasing and develop more comprehensive questionnaire for the supplier evaluation which can be easily embedded in the VeSa as RFI module. Since there are different groups of products and services purchased, i.e. hardware, software, consultancy services, there should be different types of the questionnaires accordingly.

These measures will increase the possessed variety in the system, thus will provide better control over the environment. In addition to this, S1 and S3 will also operate in more effective way.

2. System should allow doing the self-assessment and also to calculate the score and report it automatically. This measure concerns the improvement of the operations (S1), providing more autonomous mode of the work.

6.2.2 Logistics

There is rather sufficient support of the coordination mechanisms (i.e. targets for the emissions reduction, policy for the supplier evaluation) and the decision-making tool is maintained as well. However, there is lack of the autonomous operations, since in order to make decision about the carrier a buyer has to request for the calculations in the specific stand-alone application. Therefore, one of the most effective and efficient ways to improve the working process and achieve better results in the amount of the done evaluations, the calculation module should be integrated in either purchasing system which is used on the regular basis, or in the analytical tool for the optimizations. Though, a similar modification will be done in the Proxio Optimizer. These measures are related to the optimization of functions maintained by S1.

Logistics information system also needs more advanced control and audit functions. There is possibility to perform the accounting of the environmental impacts from the transportation since the basic information is available in the system (i.e. type of the carrier, distance etc.) In addition to the discussed above the decision-making tool, the “real” data from the completed activities would assure the better control over the operations through higher possessed variety and will support the intelligence function, i.e. the reliable data necessary for the decision-making to improve the logistics infrastructure will be available.

Other identified feature of the logistics information system is that there is no recursion, i.e. almost all systems are stand alone, not integrated and there is no communication with other levels. However, this problem was recognized as well by the Volvo Logistics Corporation and there is an ongoing work related to the consolidations of old separate information systems in one, which will be also integrated to the Proxio Optimizer (Erkfeldt, 2008).

6.2.3 Business traveling

The situation in the case with business traveling slightly differs from the previous cases. The primary obstacle for the effective implementation of the environmental work in this area is the lack of the coordination mechanisms, i.e. policies or guidelines which would create a framework for the system and would give a specific and clear purpose. Therefore the following suggestions can be taken into account:

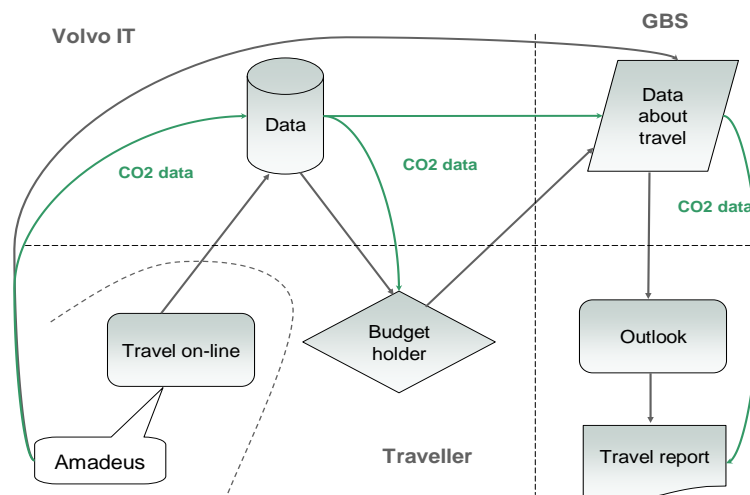
- The Global travel policy should be modified in a way when the environmental concern will be included (e.g. employees have to give preference to the train if it is possible, to share the rental car, to reduce business travel emissions etc)
- The GHG protocol (the Greenhouse Gas Protocol Initiative website) can be as an accepted tool for the unified and reliable CO2 accounting. It will give necessary guidelines for the further development of the information system. Moreover, the

methodology is widely used in the business environment, first of all for the non-financial reporting, e.g. Carbon Disclosure Project

- The “budget” for CO2 emissions (e.g. per employee, department, BA/BU) could be other coordination mechanism. This approach would be also beneficial for the more effective costs reduction since a reason of the environmental care is a core value and it would be more positively accepted by the employees. Other option is a “competition” among departments or employees with award system for those who have managed to reduce the environmental impact the most.
- Set of Key Performance Indicators based on CO2 emissions, where one of the performance indicators will be business travel emissions, is also partially coordination mechanism and partially control, since it provides the information about the current state of the environmental performance of the unit and gives a basis for the initiation of the change.

In the view of fact that there is no coordination mechanism for the environmental performance, there is no also control and audit functions as such. However, the opportunities for the effective information system with environmental information flow are identified. As we can see from the process description given in the section 5.4.3, all data about every travel booked through Travel On-line is collected and stored in the Traveler profile database. It includes the personal information of the traveler, as well as the destination and type of the transport. Therefore, considering the increasing need in the accurate environmental data, it would be possible to calculate the emissions from each travel and include it in every travel report. After discussion of the technical possibilities with Volvo IT specialists the following stages of GHG reporting could be developed (see figure 6-1):

Figure 6-1 Business travel system in Volvo Group



1. The calculations are made when all valid data about occurred travel has been submitted to the Global Business service (GBS). The calculations could be done with use of the data warehouse where all relevant information is stored (see section 2.3.3. for the additional information about data warehouses). GHG protocol is a suggested methodology according to which emissions should be accounted. Travel report, generated after, will include the data about emissions, which also will be stored in the traveler profile data base. Using this approach every traveler will be aware about own

emissions, that should have positive impact on the further decisions about the necessity of a travel. Moreover, all individual information about environmental performance will be saved in the traveler profile and the system should give also possibility to generate necessary reports about the performance of BA/BU or of the separate department. This approach will assure the sufficient control and audit functions with possibility of the double-loop learning.

2. Booking data, submitted to the data base, is processed using the information from Amadeus and travel agencies. The system, preferably, creates different options for the traveling from point A to point B, where each option is supplemented with amount of emissions generated. These options are sent to the budget holder who makes a decision about the approval of the trip and also about the route. The decision will be made considering costs and environmental impact (e.g. according to 80/20 principle). This approach will allow to make weighted decisions and to avoid extra costs. However, there is still a need to account the actual travel since different changes can happen. This modification will provide the information for the daily decision-making, thus can improve the operation function in S1.
3. Since the level of the autonomous work is quite high, i.e. Travel On-line gives the possibility to make a decision about travel to each and every employee, thus it would be beneficial for the improvement of the environmental performance to support the decision-making process with the environmental data from the travel. The data about emission can be provided during the booking, so traveler can see the approximate amount of the emissions for each travel option and use this information for the further actions guided by the travel policy. The previous stages have to be included as well. These actions will improve the viability of the system through adjustments in the operations and control functions supplemented with double-loop learning.

Certainly these changes will require quite a lot of the resources, but since the application is only becoming truly global it would be beneficial to evaluate opportunities for the automatized emissions calculations on the initial stage. Moreover, most probably the pressure from stakeholders concerning environmental performance will increase in the nearest future. However, it is important to keep in mind that the concept of recursion should be present. It means that any of the systems or elements should not work in isolation from other system levels and the integration and communication should be assured. The common data warehouse could be a useful tool for the better coordination and availability of the data. Though it is important to take into account the Travel on-line is an external tool, therefore it will be difficult to make the changes using the Volvo IT's capacity. Thus, the most feasible choice would be to follow the method proposed in the stage 1. It will fulfill the need for the environmental information and will allow the monitoring in the simple and accessible way. The existing experience in the creating similar calculation tool, EnvCalc, is a significant benefit. The most important part is the created already base for the destinations and distances between them. This part was recognized by the expert as the most complicated.

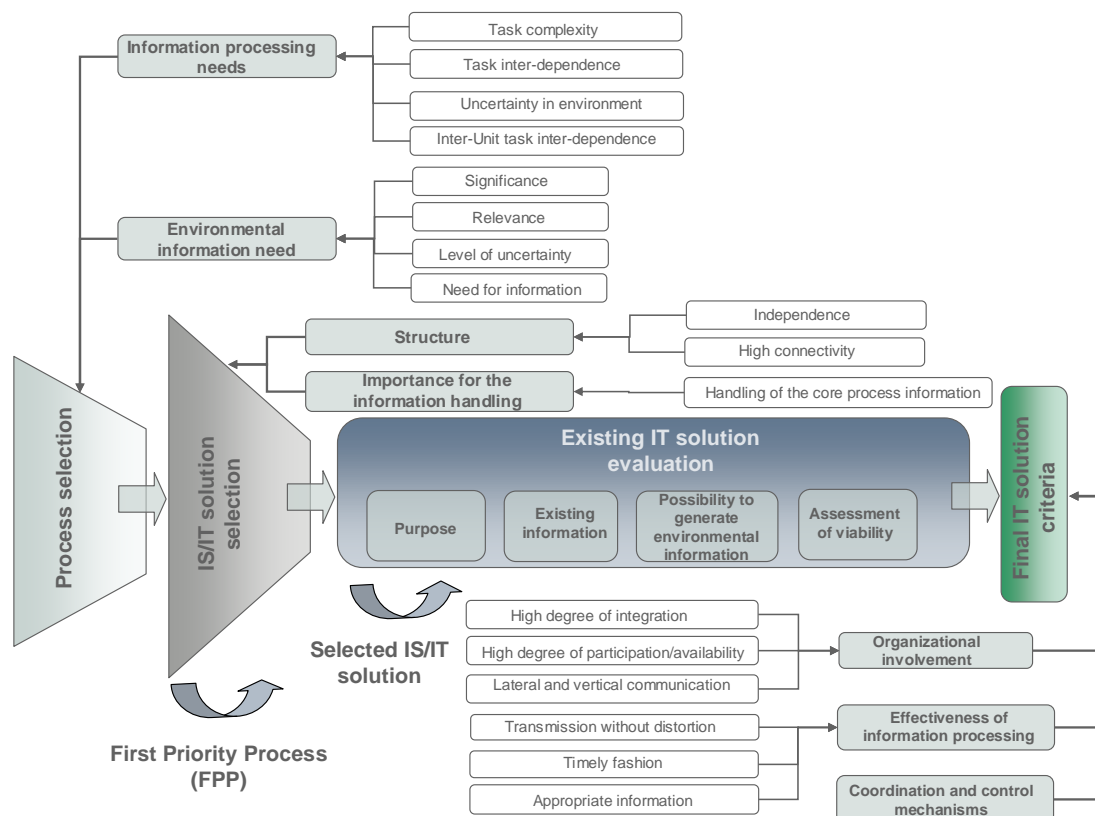
6.3 Environmental Information System Evaluation Framework (EISEF)

The purpose of this section is to describe the general methodology of the IS/IT solution evaluation. It is important to emphasize that this evaluation framework doesn't cover the environmental performance perspective only. The particular attention has been paid to the efficiency, effectiveness and viability of the IS/IT solution. The Information Processing Theory and Viable System Model were used to identify where the modifications would give

the biggest outcome and what should be done in order to achieve better environmental performance in the organization. It should assist in the design of the effective Information System which would not only provide the environmental information but would support the most effective and efficient use of it in order to achieve desirable improvements in the process as well. The IS/IT solution developed in this way should facilitate the “organizational change” by means of the changing mindset of employees concerning their daily operations.

The process approach has been used because of the particular characteristics of the studied company. Since Volvo IT provides products and services for all Volvo Group, having the history of the collaboration which lasts about 40 years, the amount of the IT solutions provided is basically enormous – more than 10 000 (see Appendix IV). They serve for the various purposes on all processes, e.g. more than 2000 applications are used in the product development process. Hence, it is quite difficult to choose the IT solution which would be helpful the most for managing of the environmental impact. So, there is a need for the selection of more specific process where the information need is the highest and the provided information is very important not only for the performance of the process but also for all organization. Other challenge is that a stand alone solution or application rarely functions well and very often uses the data from other applications, e.g. communication between KOLA (application for the product materials) and GPS (system for the global purchasing) (see Figure 5-2). Therefore, conducting evaluation in the large corporations, it is necessary to look at all information system and after select the application where the change will be the possible. Thus the following 4 steps are identified: *process selection, IS/IT solution selection, existing IS/IT solution evaluation and final IS/IT solution criteria*. These steps also represent the sequence of the current research stages. The framework is depicted in the Figure 6-2. All steps are described in the sections below with examples of argumentation from the case studies.

Figure 6-2 Environmental Information System Evaluation Framework (EISEF)



6.3.1 Process selection

According to Ashby's law, the higher uncertainty in the environment is, the higher need to possess its variety in order to reduce risks and to improve the capability of the system to control the environment. This statement concerns also the uncertainties that can be in the process itself. Therefore, it is reasonable to identify the processes with biggest uncertainty, thus high information processing needs. Tushman and Nadler (1978) categorize following sources of the uncertainties: *task complexity*, *task-interdependence*, *uncertainty in the environment and inter-unit task interdependence*. As it has been mentioned before (section 6.1.6), the purchasing process represents a good example of the process with high level of uncertainty. The task is very complex and many departments and processes in the manufacturing are dependent on the performance of the purchasing units. In addition to this, purchasing and supply management as such are characterized by high level of the uncertainty of the environment in which they operate, e.g. economical and political situation in the country of the supplier, the currency rate, reliability of their suppliers, logistics issues etc. Hence, we can come to the conclusion that the purchasing process is one of the processes with highest information processing needs. The possessed environmental information can help to reduce the uncertainties and improve communication between sub-units in the system. Highly uncertain environment with numerous suppliers and inter-dependence with other manufacturing and supporting units (like logistics) makes the process favorable for the IT-enabled changes in the IS. In addition to the improved control functions, such highly interdependent processes can have bigger influence on other aligned processes from the perspective of change inducement, e.g. pursuing environmental strategy. Evaluation of the information processing need assists in the selection of the process, where the changes will be the most efficient and effective.

Besides the information processing needs, the environmental impact in the process should be evaluated as well. The concept of the Environmental Information Need (EIN) is introduced for this purpose. This step is important from the efficiency viewpoint, since the processes with highest need in the environmental information can be identified. Four following criteria are suggested: *significance*, *relevance*, *level of uncertainty*, and *need for information*. **Significance** is related more to the environmental management system (EMS) and overall environmental strategy of the company. Significance can be assessed to any of the methodologies suggested for the evaluation of the significance of the environmental aspects where severity, probability and regulatory requirements should be considered. Since most of the organizations have an EMS in place, the significant aspects are normally identified. The important part of the environmental impact assessment is **relevance**. It is essential that the environmental impact in the process is sound with corporate strategy and policy and the management of it is relevant for the achievement of the targets or other purposes, e.g. for the voluntary non-financial reporting. The **level of uncertainty** of the environmental impact in this process should play a significant role in the selection of the process since more complex process of the accounting is, the bigger need for the IT support is. Similar argument could be applied for the criteria of the **need for information**. In this case, the processes should be evaluated on the subject is there necessary information for the management of the environmental impact in place: what existing information is used, what is missing, who needs the information and how it's used or going to be used. Therefore, looking at the selected for the study process, purchasing, and 3 areas, we can say that the environmental impact is significant (GHG emissions and suppliers performance are the most important not only in the studied BA/BUs but also for all Volvo Group), relevant (environmental impacts are included in Volvo Group policy and objectives for the reduction), they are difficult to quantify (e.g. environmental footprint of the supply chain) and there is no sufficient information available.

The process selection is essential for the identification of the most valuable process in term of the effectiveness and the scope of the positive impact. The proposed criteria can help to

detect the leverage point for the improvement of the environmental performance not only of the respective process but also all organization and other interdependent levels in the value chain, for instance suppliers or customers. However, it can be challenging for the IT provider to evaluate environmental impacts without specific expertise. Thus, there is a need for the close collaboration with process owners or environmental coordinators who are aware about the environmental impacts and the information needs. For the generalization of the environmental impact assessment of the processes following questions could be applied: **what?** (i.e. products or services related environmental impacts) and **how?** (i.e. the environmental impacts related to the internal operations, but also environmental impact from the external factors if it applicable, like in the case of the suppliers performance).

6.3.2 IS/IT solution selection

When process has been selected, then the specific IS/IT solution needs to be chosen. However, this stage can be relevant in the case when there are many different information systems or IT solutions used in one process. Such situation is typical for the big enterprises with complex processes, especially in the industries like automotive or chemical. These systems are characterized by the large information flows. If we take into account that the selected process possesses the high level of variety of the information, then in order to deal with high complexity and uncertainty, the IS/IT solution has to have features of the organismic structure. The system with organismic structure has higher ability to process information, less sensitive to the information overload and is able to handle uncertainties (Tushman and Nadler, 1978). Therefore, the sought IS/IT solution should be highly connected with other systems and be relatively independent (i.e. permit the autonomous decision-making and initiation of the corrective actions by the user). To reflect these features, the criterion “**Structure**” is proposed. The IS/IT solutions should be assessed on the subject of their dissemination and independence. For example, the global solutions used by the majority of business areas, or by business unit with comprehensive global network are the most favorable for the efficient and effective changes in the information flows or information systems in general. The global solutions are normally well connected to other information systems, e.g. financial information handling or resources management. Looking at the studied cases, the VSIB (Volvo Suppliers Information Base) is an example of the relatively organismic system. Many users are able to connect to it and use the information for the various purposes, including decision-making. The same could be said about Travel On-line application. However, as it can be concluded from the analysis there is certain room for the improvement of these systems in term of their dissemination. For instance, web-based solutions, like portals, and datawarehouses are good models for the moving towards more organismic structures.

The next feature, the effective IS/IT solution has to possess, is the **handling of the important information** for the core business, which is used on the regular basis. This parameter would help to select the system where integration of the environmental information management will be effective. In this case, the company will avoid the stand alone applications and systems which are expensive to maintain and are not used for the daily decision-making, as in the case of the logistics and EnvCalc. Other example is the selected IT solutions for the supplier evaluation and travel plan and expenses. All studied systems are the core systems with very frequent use by big amount of the employees, thus in the case of the synergy of the business process and its environmental performance management in one solution, the positive outcome will be imminent most probably.

6.3.3 Existing IS/IT solution evaluation

The stage of IS/IT evaluation includes 3 parameters which should be considered: purpose, existing information, possibility to generate environmental information. The evaluation step helps to understand how the IS/IT solution is actually used, who are the main users, what information is generated and what are the possibilities for necessary environmental information management. The viability evaluation, as it has been done on the examples of the case studies in the section 6.1., is performed on this stage too. The **purpose** is one of the most significant parameters, because in accordance with the viability system model, the lack of the purpose can lead to the collapse of a self-organizing system. Therefore it is very important for any system to have clear purpose which provides framework for their operation. The purpose is often defined by the coordination and control mechanisms, i.e. rules and procedures that regulate the process. Basically, analyzing the purpose it necessary to answer on the questions *why?* and *by whom?*. Besides the existing purpose of the solution, there is a need to think on this stage about the purpose from the environmental viewpoint, i.e. what the company wants to achieve in this process (for instance, GHG reduction from the business travel as a part of the overall company's environmental strategy). However, the differentiation between purposes of the solution should be made. This framework concentrates more on the environmental information flow and facilitating of the control of environmental impacts. However if the IT application is intended to be used for a modification of process, e.g. substitution or resource efficiency improvement, then these should be indicated. In any case, it is important to assure the reliable information management to be able to show and to track the achievements.

The **existing information** and data should be assessed on this stage. It is resulting from the assumptions and findings that the relevant environmental information, or base for its extraction, is already within the existing information system. In the most of the cases it is necessary only to interpret it in a way when this data will be useful for the environmental performance management, for instance in the form of the environmental or key performance indicators. However, sometimes the gaps in the data will be identified and the processing will require the building of the additional capacities, like datawarehouses or modifications in the solution. For example in the case of the supplier evaluation, there is the information about certification status of the supplier; however the system for the updating of the data and coordinating is missing. During the evaluation of the existing information it would be helpful to use as a guidance "need for information", defined during the process selection.

The evaluation of the existing information creates the base for the assessment of the **possibilities to generate the environmental information**. On this stage it is important to look not only at the information needs, but also at the technical possibilities. It requires the collaboration work with systems' developers and systems' owners. A number of various options can discussed, but it is essential to keep in mind that the modifications shouldn't involve large amount of the resources such as time, additional equipment, workforce etc. The efficiency concept should be of primary concern.

At the end of the evaluation process, it would be helpful to have complete assessment of the viability principles according to the structure proposed in the section 6.1. This approach will assist in the identification of the missing elements and functions, for example ability to generate up-to-date information or existence of the single source of the data. However, some of the principles were integrated in the previous steps. For instance, recursion, i.e. "system in system" feature, has been covered during the step for the IS/IT solution selection, and coordination function was included in the assessment of the environmental information need and purpose. Nevertheless, the verification of the viability could serve as a check-point in order to give more constructive and detailed instruction for the required changes as well as in the process as in the IS/IT solution itself.

6.3.4 Final IS/IT solution criteria

When the decision about the modification is taken, the further work should be guided by the criteria for the final IS/IT solution. These criteria reflect the features of the effective and efficient environmental information management, i.e. the information generated is necessary and relevant, has the high quality and communicated in a way when the data is used in order to improve environmental performance of the process. The multi-disciplinary approach is taken to achieve the efficiency and effectiveness of the selected IS/IT solution. The organizational involvement, effectiveness of the information processing and coordination and control mechanisms define the success of the IS/IT solution. These parameters are selected on the basis of the Information Processing Theory (IPT) and target for the formation of the preferred fit between information processing needs (IPN) and information processing capacity (IPC). These criteria reflect also the requirements for the viable systems, discussed in the section 6.1.

The **organizational involvement** is the prerequisite for the effective use of the environmental information and formation of the information processing capacity. In order to deal with uncertainties in the system and its environment and to assure it in the best possible way, changing the behavior within organization on various levels, IS/IT solution has to possess the high degree of the integration, high degree of the participation or availability and to provide lateral and vertical communication. All these factors support the diffusion principle, when authority for taking actions and responsibility for the environmental performance are disseminated, and don't constitute the authority and responsibility of the environmental manager or coordinator only. This approach allows involving the employees who run/own the main business process on the daily basis and provides synergy of the business and environmental care.

The aspects of the degree of integration has been discussed already in the section 6.3.2, and it can be assumed that selected solution is integrated in a certain extend. High degree of the participation is characterized by the number of the users on the different steps of the value chain. For instance, if a system with information about environmental performance of the process or organization provides access to a large number of the employees, it is most probably that the environmental awareness will increase and the targets will be achieved. Basically, looking at these criteria, organizational involvement is related to the information transparency as well. Lateral and vertical communication is also close to the issue of information transparency, but besides this it reflects the notion that various levels of the organization have different IPC. Thus, for the effective use of the information, it should be communicated not only in horizontal way, e.g. manufacturing, but also it should be accessible and understandable by the management or other interested parties which can have an influence on the strategic decision-making (e.g. communication team, internal auditors, regulatory authorities etc.). For instance, suggested improvements for the travel plan and expenses solution cover these aspects: data warehouse provides the lateral and vertical communication; the proposed changes will assure very high level of the participation and independence for the decision-making. All these factors support the diffusion principle, when authority for taking actions and responsibility for the environmental performance are disseminated, and don't constitute the authority and responsibility of the environmental manager or coordinator only. This approach allows involving the employees who run/own the main business process on the daily basis and provides synergy of the business and environmental care.

The **effectiveness of information processing** describes the requirements to the quality of the information. However, the quality is viewed not only from the perspective of the data precision, but also the way how it is communicated. Thus, IS/IT solution should be able to

handle the *appropriate* information in a *timely fashion* and *transmitted without distortions*. The concept of the appropriateness includes the relevance, discussed in the section 6.3.1 “Process selection” and covers partially the lateral and vertical communication. Basically it’s related to the form in which information is presented or available. It should be understandable, useful for the decision-making on the various levels and allows the follow-up the company’s targets and objectives. It is recommended to develop a set of the environmental performance indicators. The methodology proposed by Schaltegger and Buritt (2002) is an example of the approach to the systematic collection of the eco-efficiency indicators for different users. The timely fashion is important for the proper functioning of the operation and coordination systems (see 6.1.1). Besides this, it assures the control and auditing functions since the “real-time” information is available in order to detect the deviations and to initiate corrections in the system. For instance, in the case of the supplier evaluation and tracking the KPI concerning the certification rate, the information is not up-to-dated; it’s not possible to generate the report with reliable data, and therefore the support for the supplier selection and control function is not provided.

Availability of the **coordination and control mechanisms** is also important for the improvement of IPC. Moreover, according to the VSM, coordination and control mechanisms play the vital role for the viability of any system. They include rules and procedures, planning and control systems, and coordinating units such as task forces. “... the more complex, elaborate, and comprehensive the coordination and control mechanisms are, the greater the ability to process information and deal with inter-unit uncertainty” is stated in the work of Tushman and Nadler (1978). It means, that the purpose and operation of the final IS/IT solution should be guided by or provide support to the coordination and control mechanisms, and the more they are elaborated and comprehensive, more the system is viable and unconstrained in its adaptation to environment.

6.4 Practical suggestions for the application of the Environmental Information System Evaluation Framework (EISEF)

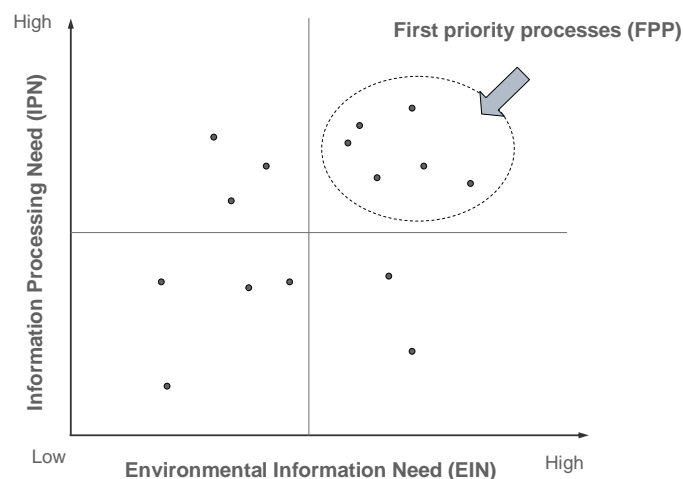
Even though, the general explanation of the basic evaluation steps is given in the section 6.3, it would be still helpful to provide practical recommendation for the use of the framework, since the model has been developed after aligning the knowledge obtained from various sources. It is a particular feature of the design science approach, i.e. the prescriptions for the further actions form the tool which is developed on the foundation of the scientific theories. Hence, there is need to demonstrate the “inverse” process which suppose to be used in the practice. Considering strategy for the integration of the environmental information management proposed by Molloy (2007), EISEF could be applied for the “as-is analysis”, i.e. for the strategic situation analysis when the current situation with IT support of the environmental management is assessed. However, EISEF can also support in the strategic development and strategic action planning, since it provides the clear requirements for the IS/IT solutions on the evaluation stage and also for the final product.

It is important to emphasize that the framework has been developed coming from the assumption that there is the highly developed IT infrastructure in the large enterprise with numerous IS/IT solutions. The appropriate IT solution selection for the generation of data about environmental impacts of the company was one of the major obstacles at the beginning of the research. Therefore, as the result, it has been accepted that the process where the company wants to improve performance should be selected first. Considering this, it has been decided to propose the criteria for the process selection which would assist in the choice for the process where the information need, including environmental information, is the highest and environmental impact is the most significant and relevant. In addition to this, there is also

possibility to choose the process where the environmental information handling would give the large positive influence of the environmental performance of the organization, reducing the risks related to the uncertainties and improving overall control over process and its environment.

Thus, looking at the proposed criteria for the process selection (Figure 6-2), the company can do the plotting of the processes, where Environmental Information Need (EIN) and Information Processing Need (IPN) parameters will be as the axes on the graph. The certain score range can be assigned to each of the criterion, and then the total score for the information needs represent a sum. For example, uncertainty in the environment can range from very low (0) to very high (5). It is recommended to have the same weight for each of the criterion in order to avoid complications. Moreover, both types of the information needs are equally important. The main drawback for this method is that it's rather qualitative and subjective, therefore it is recommended to involve for assessment the multi-disciplinary team. After the process scoring, the results can be plotted on the graph, which will look like it is shown on the Figure 6-3.

Figure 6-3 Process selection plot



After the first priority processes (FPPs) are selected the further work on the appropriate IS/IT solution can be continued. It would be beneficial to have a set of the environmental performance indicators (EPIs) in place when analysis of the system is conducted. It can help in the identification of the IS/IT solution where the relevant environmental information will be generated. In any case, the proposed criteria for this step are related to the ability of the IS/IT solution to handle the information, providing it to the largest number of the employees and other stakeholders. Hence, the highly connected to other systems and solutions IS/IT solution, as well as used by the large number of the users, should be considered in the first place. In order to fulfill the requirements for the effectiveness of the environmental information management, it is also recommended to select the process where the core business process information is handled, like it has been done for the case studies: supplier evaluation – VSIB and VeSa, travel plan and expenses – Travel on-line, logistic – Proxio Optimizer.

The third step of EISEF aims for the evaluation of the selected IS/IT solution on the subject of the ability to provide the environmental information in the efficient and effective way. As it

has been emphasized in the section 6.3.3, it is important to have clear purpose for the sought information and thus solution itself. However, since the relevance and significance of this information has been assessed on the process selection stage, most probably the purpose for the selected IS/IT solution can be formulated fairly easy. The search for the necessary data in the existing information should be supported by the purpose and, consequently, requirements to the type of the information, e.g. as a key performance indicator for the reporting of the environmental performance in the sustainability report or performance indicators for the efficiency improvement plan or lean production. The development of the EPIs can be supported by the numerous guidelines, e.g. ISO 14031 standard, GRI guidelines etc. (see section 2.2.2 concerning performance measures).

The stage for the existing IS/IT solution evaluation encompasses also technical consultations with software developers since it is essential to find the solution with least possible cost. The final step of the evaluation is the assessment according to the viability principles applied in the section 6.1 and 6.2. Suggested “check-list” in the Table 6-1 can be used for the visualization of the main problems related to the effectiveness of the environmental information management. Various deficiencies can be identified on this stage. It can happen that there is a missing corporate policy or procedure concerning the environmental impact, like in the case with business travel; or lack of the autonomous decision-making based on the provided information like in the case of the logistics, or there is no up-to-date information provided according to the existing policies and procedures. Therefore, as we can see, sometimes the problems are related not to the IT system or software itself, but more to the general corporate information system, where all information (e.g. procedure, policy, action plans, standards etc) are handled. In this case, EISEF and VSM, in particular, assist the organization in the more efficient and effective total environmental management, where the relevant information management through IT systems is only a part of it.

When the necessary changes are identified, the request for the change can be submitted. The Final IT Solution Criteria can assist in the description of the technical requirements for the IT solution, if they are not fulfilled yet. The criteria also can guide the process managers in the development of the necessary information infrastructure around IS/IT solution, e.g. if there is a need for the development of the more detailed plan with targets for the improvement according to the corporate policy or if EPIs are required for the integration in the IS/IT solution. Basically this step describes the “to-be” situation, i.e. what functions IS/IT solution should have.

Even though, the described recommendations are proposed for the evaluation of the existing information system, EISEF can be applied also for the new developing IT solutions. For example, in the situation when the process manager comes with request to develop an application for the management of the particular aspects of the process. Then, this application should be evaluated from the perspective of the relevant environmental information handling too. In this case, company can move towards the complete integration of the environmental management in every aspect of the business activity.

7 Conclusions and Recommendations

First of all, the analysis of the completed work in relation to the research purpose is provided in this chapter, followed by concise answers to the research questions. In addition to this, some recommendations of future focus areas for the case study company and IT providers in general are given. The chapter is concluded with suggestions for further research. Section 2.4 can be taken into account as a part of the general conclusions and contains summarized observation obtained from literature review.

7.1 Answers on the research questions

The principal purpose of the current research is related to the extension of operational functionalities of Business Information Systems, where the possibilities for support of environmental work in the organization have been reviewed. Concerning the first research question **“How can Business Information Systems (BIS) help to improve the environmental performance of organizations?”** it is found that there are a number of potentials of BIS to enable the improvement of the environmental performance of the organization:

1. *Efficient collection, storing, processing and communication of environmental information.* This aspect is especially important due to the increasing demands for quantity and quality of environmental information necessary for regulatory compliance and various voluntary initiatives.
2. *Effective integration of environmental matters in the core business processes.* It gives the opportunity for an organization to go beyond compliance, improving the processes and providing more proactive initiatives for competitive advantage.
3. *Involvement of the employees from all organizational levels* providing the opportunity for autonomous informed decision-making concerning their day-to-day operations.
4. *Increased environmental awareness* within an organization as a prerequisite for environmental performance improvement. Provided knowledge, as a part of awareness, is a starting point for the change of individuals' thinking, values, attitudes and indirectly their behavior

Despite the identified opportunities for environmental performance improvement, it is found that BISs are not deployed to the full extent when environmental management is supported and facilitated. The main reasons are associated with the complexity of the environmental matter as well as the low level of awareness of environmental issues and organizational needs among IT professionals who support the IT infrastructure in the organization. However, it is observed that the latter aspect is becoming less relevant. The increased attention to the growing energy consumption of IT equipment and electronic waste brings the environment to the agenda of top management and Chief Information Officers. In order to reduce costs related to the IT infrastructure, the environmental aspect of increased efficiency and functionality of Information Systems is viewed as an opportunity to bring higher benefits to the organization.

Thus, the answer to the second research question **“How can business Information Systems and Information Technology solutions be integrated in an organization to improve the environmental performance in terms of efficiency and effectiveness?”** aims to provide the guidelines for IT professionals to extend functionality of the BIS. The developed

Environmental Information System Evaluation Framework (EISEF) represents the main outcome of the research process. Four steps of the EISEF include the criteria which support the efficient and effective integration of environmental information flow in the BIS. The concept of Environmental Information Need (EIN) is introduced as one of the parameters for the first priority process (FPP) selection. Application of cybernetics and organizational theories allowed alignment of the cognitive and organizational parameters of the end user in the evaluation approach. The Viability System Model is applied to the assessment of the ability of the studied IS/IT solutions to provide the environmental information according to the features of self-organizing systems. The framework can be applied for the evaluation of existing IS/IT solutions used as guidance for IS/IT solutions in the development and deployment phases.

7.2 What else can Volvo IT do to be a driving force?

Since the strategy of Volvo IT is to be the Business Solution provider, the environmental perspective in their products and services can bring a new dimension to customers' satisfaction. Moreover, it has been identified that there is a high need for support in the environmental work by IT. The environmental care can give the possibility to create more value and to identify synergies in Volvo group. Therefore, it is recommended to consider the opportunity for assurance of the environmental information flow in the corporate Information System. It is especially relevant to the current stage when the process of consolidation and globalization of IT infrastructure takes place throughout the Volvo Group. It can make the necessary changes in the IS/IT solutions more efficient since changes after the solution are global, more complex and require more resources.

Besides the opportunities identified in the previous section, the integration process can bring other benefits for Volvo Group:

- Improved communication and collaboration between Business Areas and Business Units;
- Strengthened image of Volvo as a brand with a strong environmental policy.

Environmental information flow as such does not exist in the IT system of Volvo Group; therefore it would be beneficial for the company to consider future strategy at an early stage. The first step should be review of environmental policies and identification of key measures that should be monitored in Volvo Group, including the specific measures for the BA/BUs. The set of eco-efficiency indicators where environmental performance figures are connected to economic figures should be developed. These indicators should be in line with general corporate strategy and policy reflecting environmental objectives and targets. In other words environmental performance and core process performance should be integrated as much as possible. However, this process can be time consuming, since many various aspects should be taken into account, where the data accessibility; intended use, avoiding mismatch between data required by top-down process (for stakeholders) and bottom-up process (operational); and compliance with regulation are the main obstacles. In order to initiate the integration process, the existing environmental performance measures can be used, as seen in the case of supplier evaluation.

The next steps can be in accordance with the Environmental Information System Evaluation Framework. The process plotting can be performed by each BA/BU separately with involvement of key personnel from each global process, environmental department and IT support. It is especially relevant for the management of environmental impacts by means of the information systems since the IT provider usually does not have the required

environmental management knowledge more commonly found in manufacturing fields. Another opportunity to acquire the necessary knowledge about major environmental issues is regular participation in the environmental council of the Volvo Group. Since Volvo IT has not participated before in this council, it can be also used for the communication of plans and capabilities in terms of environmental care.

The IT solution selection can be a very challenging process for Volvo IT. However, the preference for global and core solutions can facilitate the selection. Since there are Enterprise Resource Planning systems in place already, it would be beneficial to evaluate them in the first turn. These systems are able to assist in the materials flows accounting on a more regular basis. This can help to improve the efficiency of some processes, reduce material consumption and comply with regulation.

In many cases it will be rather complicated to make a change within systems. Therefore, the main role of Volvo IT should be the assurance of availability of high quality, updated, reliable and necessary information. The data warehouses can be a good solution for it. This can support the integration of various systems using similar information and providing data in the format according to the user-profile (e.g. costs, relative performance indicators, eco-efficiency indicators etc). The data warehouses should be able to create the required user reports. This approach can also support the company in pursuing the directions within the objective "Global provider". Besides this, data warehousing is the integration strategy which complies with requirements for the viable information system according to VSM.

The general recommendation is to consider proposed criteria for IS/IT solutions in the IS-GDP. However, these criteria cover only part of the environmental aspects related to the IS performance. The work of Standing & Jackson (2007) is a good general approach to the sustainability of information systems. The additional aspect that should be taken into account is the measurement of second order effects of IS/IT solutions, i.e. indirect impacts. This information is valuable for the performance of the IT provider as well for the communication of this data to existing or potential customers.

It can be quite challenging in the case of the environmental information system, since it is basically impossible to predict how the provided information will be used by decision-makers and what it will bring to the environmental performance improvement of the organization or process. However, it could be possible if the impact or value of the indicator is known before implementation of the changes, then improvement could be monitored. Another approach is to apply the sustainability-maturity model proposed by Standing & Jackson (2007). In cases when the IS/IT solution is used directly for the substitution or efficiency improvement, as in the case of the emballage management system or applications for virtual meetings, the performance of IS/IT solution can be measured according to the actual outcome.

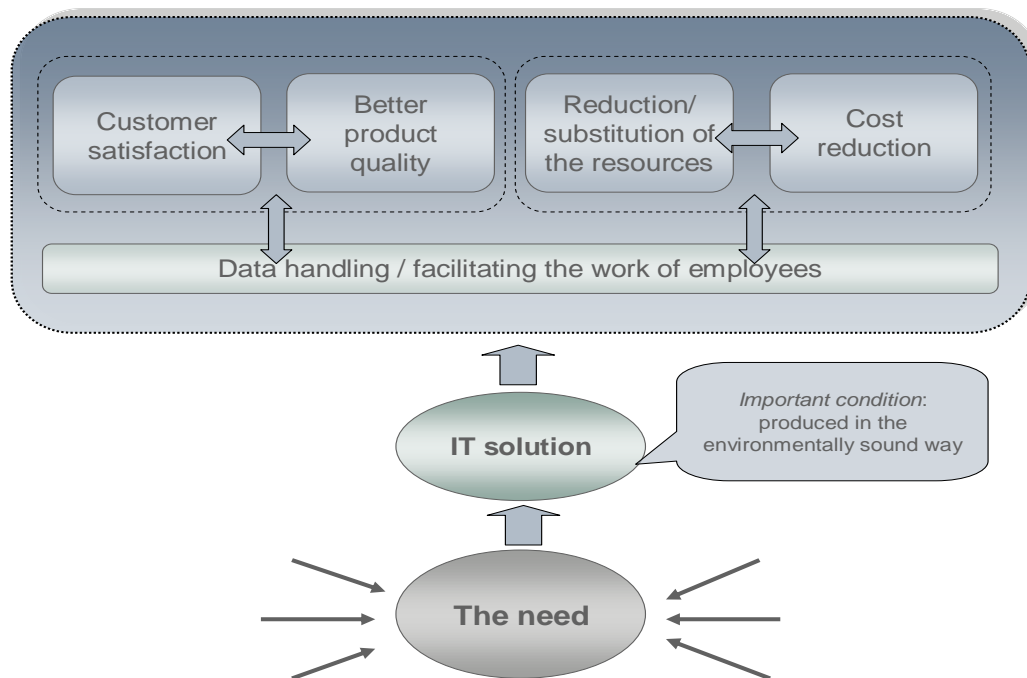
7.3 General implications for IT providers

Environmental perspective in the IS is not a matter of development of new environmental software, but rather looking at IT from a new angle in addition to quality and security parameters. This approach is able to provide a better value of products and services to the customers, thus higher satisfaction and improved collaboration. The need for environmental management expertise in the development of business IT solutions is the main implication of findings for the IT providers. It can be achieved by means of the involvement of experts in environmental management, who can be a representative from the customer side or any external professional.

Even though this thesis examines the benefits of BIS for the environment only from the efficient and effective handling of the environmental information viewpoint, it is important to consider other possibilities of IT for sustainable development. The role of a business IS/IT solution for sustainability can be depicted as it shown in Figure 7-1. This model can assist in the guidance of general strategy for the development of new applications, where economic, environmental and social aspects should be taken into account. However, the essential point is that “The need” should be a driver for IT solutions.

For instance, Software Working Group¹⁰ of the non-profit business association Business for Social Responsibility specifies the following types of needs: business challenge, customer demand, social and environmental need, and government concern (BSR, 2008). The model proposed in the report “Software Accelerates Sustainable Development” published in August 2008 is similar to that suggested in this thesis (Figure 7-1), but the aspects of “environmental benefits, profit and social benefits” are more elaborated. The key point is that the environmental care in the software is not only facilitating compliance with regulation, but it is also able to provide substantial economic benefits through improved efficiency and thus cost reduction. However, the issue of resource consumption during production of the IT solutions should not be omitted either.

Figure 7-1 IT solution and conditions for the sustainable growth of an IT provider



7.4 Contribution and future research needs

It is important to understand the nature of the organization since it is a prerequisite for its cognitive perception, and thus effectiveness. That is why it is essential to perform multi-disciplinary research where knowledge about the structure of the organization and Information Systems is combined with expertise in the environmental field. Since “natural

¹⁰ The companies in the Software Working Group are Adobe, Autodesk, HP, McAfee, Microsoft, SAP and Symantec (BSR, 2008)

science aims at understanding and explaining phenomena; design sciences aims at developing ways to achieve human goals” (March and Smith, 1995), there is the need to do both in further research in the field of sustainability of information systems. In addition to it, it is also necessary for the understanding of integration between IS and the Organization as well as for the prescription of required actions. This approach can prevent the information systems’ failure, because nothing works in isolation from each other neither organization, nor information systems and not even the impact of the organization on the environment. For example, knowledge acquisition and learning organization can be the next aspects to be considered in the environmental information management by means of Information Systems.

The main contribution of the research work and its outcomes has scientific and practical implications. First of all, the cybernetic theories have been tested for assessments of the information systems from environmental viability viewpoint, and Organizational Information Processing Theory is used for the development of specific criteria for all steps of the evaluation framework. According to the literature review, the analogous approach has not been used before for this purpose.

Since the issue of environmental sustainability and IS is still in its infancy, the proposed practical approach for the integration of environmental management issues in the IS is valuable for IT providers. However, it would be beneficial if this method is tested for other information systems and IT solutions in different types of organizations. Supplementing the framework with specific questionnaires and values for the proposed criteria would facilitate practical application.

Bibliography

- Beer, S. (1984). The Viable System Model: Its Provenance, Development, Methodology and Pathology. *The Journal of the Operational Research Society*, 35(1), 7-25. Retrieved July 28, 2008, from <http://www.jstor.org/stable/2581927>.
- Bennett, M., & James, P. (1997). Environment-Related Management Accounting: Current Practice and Future Trends. *Greener Management International*, 17, 32-51.
- Beucker, S., Lang, C., Rey, U., & Orbach, T. (2002). Computer Aided Resource Efficiency Accounting: Assessing and Communicating Environmental Impacts and Costs along Supply Chain. In *Environmental Communication in the Information Society* (Vol. 2, pp. 438-445). Vienna.
- BSR. (2008). *Software Accelerates Sustainable Development*. Business for Social Responsibility. Retrieved from http://www.bsr.org/reports/BSR_Software_Accelerates_Sustainable_Development.pdf.
- Burmam, A., & Gómez, J. (2007). Data Warehousing with Environmental Data. In *Information Technologies in Environmental Engineering* (pp. 153-160). Retrieved July 7, 2008, from http://dx.doi.org/10.1007/978-3-540-71335-7_17.
- Burritt, R. (2005). Challenges for Environmental Management Accounting. In *Implementing Environmental Management Accounting: Status and Challenges* (pp. 19-44). Retrieved August 14, 2008, from http://dx.doi.org/10.1007/1-4020-3373-7_2.
- Carlander, M. (2008). Volvo IT is an attractive partner. *UseIT*, (2). Retrieved from <http://useit.volvoit.com/>.
- Carlsson, A. (2008, July 1). Personal interview. .
- Carr Nicholas G. (2003). IT doesn't matter. *Harvard Business Review*, 81(5), 41-49.
- Carr, N. G. (2004). *Does IT Matter? Information Technology and the Corrosion of Competitive Advantage* (1st ed., p. 208). Harvard Business School Press.
- Christensson, C. (2008, June 4). Personal interview. .
- Chu, Y., Young, C., & Yang, C. (2002). Integrating Environmental Information through Data Warehousing with Data Quality Assurance. In *Environmental Communication in the Information Society*, Vienna.
- Coakes, E., & Elliman, T. (1999). Focus Issue on Legacy Information Systems and Business process Change: the Role of Stakeholders in Managing Change. *Communications of the Association for Information Systems*, 2, article 4.
- Corporate Register. Charts. . Retrieved September 4, 2008, from <http://www.corporateregister.com/charts/bytype.htm>.
- CorporateRegister. (2008). *The CSR Assurance Statement Report*. Retrieved from <http://www.corporateregister.com/pdf/AssureView.pdf>.
- Donley Technology. (2008). Environmental Software Information. . Retrieved September 2, 2008, from <http://www.donleytech.com/>.
- El-Gayar, O. F., & Fritz, B. D. (2006). Environmental Management Information Systems (EMIS) for Sustainable Development: a Conceptual Overview. *Communications of the Association for Information Systems*, 17, 756-784.
- Encyclopedia Britannica. (2008). information system. In *Encyclopedia Britannica*. Retrieved July 24, 2008, from <http://search.eb.com.ludwig.lub.lu.se/eb/article-9126502>.
- Erkfeldt, H. (2008, August 11). Personal interview. .
- ESP. (2008a). ESP – Environmental Software Providers > Products > Overview. . Retrieved September 4, 2008, from <http://www.esp-net.com/Products/Overview/tabid/77/Default.aspx>.
- ESP. (2008b). Using opsEnvironmental for Compliance Management at General Motors. . Retrieved September 4, 2008, from <http://www.esp-net.com/Customers/CaseStudies/tabid/92/Customers/CaseStudies/GeneralMotors/tabid/276/Default.aspx>.
- Espejo, R., & Watt, J. (1988). Information Management, Organization and Managerial Effectiveness. *The Journal of the Operational Research Society*, 39(1), 7-14. Retrieved July 27, 2008, from <http://www.jstor.org/stable/2581993>.

- Esty Daniel. (2007). Green Is Beautiful ; Helping the planet doesn't have to hurt your bottom line. Environmentally responsible IT can improve efficiency and generate new revenue streams. *CIO*, 20(6), 1.
- Esty, D. C., & Winston, A. S. (2006). *Green to Gold: How Smart Companies Use Environmental Strategy to Innovate, Create Value, and Build Competitive Advantage* (1st ed., p. 384). Yale University Press.
- Fairbank James F, Labianca Giuseppe, Steensma H Kevin, & Metters Richard. (2006). Information Processing Design Choices, Strategy, and Risk Management Performance. *Journal of Management Information Systems*, 23(1), 293-319.
- Gebauer Judith, & Lee Fei. (2008). Enterprise System Flexibility and Implementation Strategies: Aligning Theory with Evidence from a Case Study. *Information Systems Management*, 25(1), 71-82.
- Goscinski, J. (2007). Development of a Software-based Environmental Reporting According to the "Bundes-Immissionsschutzgesetz". In *Information Technologies in Environmental Engineering* (pp. 567-574). Retrieved July 7, 2008, from http://dx.doi.org/10.1007/978-3-540-71335-7_55.
- GRI. (2008). GRI - Home Page. . Retrieved March 7, 2008, from <http://www.globalreporting.org/Home>.
- Grünwald, C., & Gómez, J. (2007). Conception of System Supported Generation of Sustainability Reports in a Large Scale Enterprise. In *Information Technologies in Environmental Engineering* (pp. 61-68). Retrieved July 7, 2008, from http://dx.doi.org/10.1007/978-3-540-71335-7_9.
- Haigh Nardia, & Griffiths Andrew. (2008). The environmental sustainability of information systems: considering the impact of operational strategies and practices. *International Journal of Technology Management*, 43(1), 48.
- Harvard Business School Press. (2007). *Harvard Business Review on Green Business Strategy (Harvard Business Review Paperback Series)* (p. 204). Harvard Business School Press.
- Holmqvist, M. (2008, May 23). Personal interview. .
- Huber, G. P. (1991). Organizational Learning: The Contributing Processes and the Literatures. *Organization Science*, 2(1), 88-115. Retrieved September 9, 2008, from <http://www.jstor.org/stable/2634941>.
- Hutter, J. (2001). Environmental Management Information Systems or the Integration of the Corporate Environmental Department into ERP. In *Sustainability in the Information Society* (Vol. 1, pp. 297-302). Zurich, Switzerland.
- Intellect. (2008). *High Tech: Low Carbon. The Role of Technology in Tackling Climate Change* (p. 52). Retrieved from [http://www.intellectuk.org/component/option,com_docman/task,cat_view/gid,262/Itemid,102/?mosmsg=You+are+trying+to+access+from+a+non-authorized+domain.+ \(www.google.se\)](http://www.intellectuk.org/component/option,com_docman/task,cat_view/gid,262/Itemid,102/?mosmsg=You+are+trying+to+access+from+a+non-authorized+domain.+ (www.google.se)).
- Isenmann, R., & Lenz, C. (2001). Customized corporate environmental reporting by internet-based push and pull technologies. *Eco-Management and Auditing*, 8(2), 100-110.
- ISO. (1999, November). EN ISO 14031 Environmental management - Environmental performance evaluation - Guidelines. . International Organization for Standardization.
- ITGI. (2008). ITGI. . Retrieved October 7, 2008, from <http://www.itgi.org/>.
- Kästner, T. (2007). Concept to Migrate an Access Based Environmental Information System into a Web-based Front-end Solution for the Environmental Management of a Waste Disposal Company. In *Information Technologies in Environmental Engineering* (pp. 559-566). Retrieved July 7, 2008, from http://dx.doi.org/10.1007/978-3-540-71335-7_54.
- Kim Kyung Kyu, Umanath Narayan S, & Kim Bum Hun. (2006). An Assessment of Electronic Information Transfer in B2B Supply-Channel Relationships. *Journal of Management Information Systems*, 22(3), 293-320.
- Lang, C., Heubach, D., & Loew, T. (2005). Using Software Systems to Support Environmental Accounting Instruments. In *Implementing Environmental Management Accounting: Status and Challenges* (pp. 143-168). Retrieved August 14, 2008, from http://dx.doi.org/10.1007/1-4020-3373-7_8.
- Larsson, L. (2008, June 19). Personal Interview. .
- Lewis, G. J. (1997). A cybernetic view of environmental management: the implications for business organizations. *Business Strategy and the Environment*, 6(5), 264-275.
- Lewis, G. J., & Stewart, N. (2003). The measurement of environmental performance: an application of Ashby's law. *Systems Research and Behavioral Science*, 20(1), 31-52.
- M. Bensaou, & N. Venkatraman. (1995). Configurations of Interorganizational Relationships: A Comparison between U.S. and Japanese Automakers. *Management Science*, 41(9), 1471-1492.

- Makarova, Y. (2008). *Accounting of the Business Travel Related Emissions. Experience of Swedish companies* (p. 35). Lunds universitet: the International Institute for Industrial Environmental Economics.
- March, S., & Smith, G. (1995). Design and natural science research on information technology. *Decision Support Systems*, 15(4), 251-266.
- Mårtensson, L. (2008, July 2). Personal interview. .
- Mayer, T. (2001). Software for the Material Flow Management - Market Overview and Practical Insight. In *Sustainability in the Information Society* (Vol. 1, pp. 279-286). Zurich, Switzerland: Metropolis Verlag.
- Molloy, I. (2007). Environmental Management Systems and Information Management — Strategic-Systematical Integration of Green Value Added. In *Information Technologies in Environmental Engineering* (pp. 251-260). Retrieved July 7, 2008, from http://dx.doi.org/10.1007/978-3-540-71335-7_26.
- Moore Margery A. (2002). A strategic, systems approach to understanding environmental management information systems. *Environmental Quality Management*, 11(4), 65-73.
- NEC. (2008). Glossary: Environmental Activities | NEC. . Retrieved September 11, 2008, from <http://www.nec.co.jp/eco/en/annual2006/16/i.html>.
- Nemcsicsne Zsoka, A. (2008). Consistency and "awareness gaps" in the environmental behaviour of Hungarian companies. *Journal of Cleaner Production*, 16(3), 322-329.
- Nonaka, I. (1994). A Dynamic Theory of Organizational Knowledge Creation. *Organization Science*, 5(1), 14-37. Retrieved September 9, 2008, from <http://www.jstor.org/stable/2635068>.
- Olsson, M., & Sjöstedt, G. (2004). *Systems Approaches and Their Application: Examples from Sweden* (1st ed., p. 340). Springer.
- Orsato Renato J. (2006). Competitive Environmental Strategies: WHEN DOES IT PAY TO BE GREEN ? *California Management Review*, 48(2), 127-143.
- Park, J., & Brorson, T. (2005). Experiences of and views on third-party assurance of corporate environmental and sustainability reports. *Journal of Cleaner Production*, 13(10-11), 1095-1106.
- PCmagazine. (2008). information system Definition. . Retrieved September 6, 2008, from http://www.pcmag.com/encyclopedia_term/0,2542,t=information+system&i=44963,00.asp.
- Peta Darke, Graeme Shanks, & Marianne Broadbent. (1998). Successfully completing case study research: combining rigour, relevance and pragmatism. *Information Systems Journal*, 8(4), 273-289.
- Premkumar G, Ramamurthy K, & Saunders Carol Stoak. (2005). Information Processing View of Organizations: An Exploratory Examination of Fit in the Context of Interorganizational Relationships. *Journal of Management Information Systems*, 22(1), 257-294.
- Proxio AB. (2008). proxio. . Retrieved September 7, 2008, from <http://www.proxio.se/>.
- Qu, G., Ji, S., & Min, Q. (2008). Inter-Organizational Coordination, IT Support, and Environment. *Tsinghua Science & Technology*, 13(3), 374-382.
- Richert, L. (2008, May 26). Personal interview. .
- Rikhardsson, P., & Kraemmergaard, P. (2006). Identifying the impacts of enterprise system implementation and use: Examples from Denmark. *International Journal of Accounting Information Systems*, 7(1), 36-49.
- Rikhardsson, P., Bennett, M., Bouma, J., & Schaltegger, S. (2005). *Implementing Environmental Management Accounting: Status and Challenges*. Retrieved July 6, 2008, from <http://dx.doi.org/10.1007/1-4020-3373-7>.
- Rikhardsson, P. M. (1998). Information systems for corporate environmental management accounting and performance measurement. *Greener Management International*, (21), 51-70.
- Rikhardsson, P. M. (2001). Corporate environmental management and information technology. *Eco-Management and Auditing*, 8(2), 90-99.
- Schaltegger, S., & Burritt, R. (2000). *Contemporary Environmental Accounting: Issues Concepts and Practice* (p. 462). Greenleaf Pubns.
- Schaltegger, S., & Wagner, M. (2005). Current Trends in Environmental Cost Accounting — and Its Interaction with Ecoefficiency Performance Measurement and Indicators. In *Implementing Environmental Management Accounting: Status and Challenges* (pp. 45-62). Retrieved August 14, 2008, from http://dx.doi.org/10.1007/1-4020-3373-7_3.

- Schulze, B. (2002). Enterprise Resource Planning Systems as a Platform for Managing Corporate Environment, health and Safety Processes Shown by the Example of SAP EH&S. In *Environmental Communication in the Information Society* (Vol. 1, pp. 296-303). Vienna.
- Shih-Wei Chou, Mong-Young He, & Pi-Yi Chen. (2008). The Factors that Affect the Implementation Success of IS. In *Proceedings of the 41st Annual Hawaii International Conference on System Sciences (HICSS 2008)* (p. 421).
- Skoglund, C. (2008, June 13). Personal interview. .
- Standing, C., & Jackson, P. (2007). An approach to sustainability for information systems. *Journal of Systems and Information Technology*, 9(2), 167 - 176. doi: 10.1108/13287260710839247.
- Steen, B. (1999). *A systematic approach to environmental priority strategies in product development (EPS). Version 2000 - General system characteristics*. Chalmers University of technology, Technical Environmental Planning. Retrieved from http://www.cpm.chalmers.se/document/reports/99/1999_4.pdf.
- Sweeney Judy, & Jacobson Simon. (2007). ERP Breaks. *Industry Week*, 256(1), 11A,12A,13A.
- the Greenhouse Gas Protocol Initiative website. Greenhouse Gas Protocol » All tools. . Retrieved March 7, 2008, from <http://www.ghgprotocol.org/calculation-tools/all-tools>.
- Tushman Michael L., & Nader David A. (1978). Information Processing as an Integrating Concept in Organizational Design. *Academy of Management. The Academy of Management Review*, 3(3), 613.
- UNEP. (2007). Life Cycle Management. A Business Guide to Sustainability. . UNEP.
- Volvo Group. (2003, June 13). Code of Conduct. .
- Volvo Group. (2006). Key Elements Procedure 5. Environmental Requirements. .
- Volvo Group. (2008a). Violin. . Intranet, . Retrieved September 7, 2008, .
- Volvo Group. (2008b). Supplier Evaluation Model. .
- Volvo IT. (2007). UseIT No.4 2007. . Retrieved September 10, 2008, from http://useit.volvoit.com/magazine/useit/2007_04/index.htm.
- Wemme, L. (2008, May 19). Personal interview. .
- Willard, B. (2002). *The Sustainability Advantage: Seven Business Case Benefits of a Triple Bottom Line* (p. 240). New Society Publishers.
- Wohlgemuth, V., Niebuhr, C., & Lang, C. (2004). Exchanging Environmental Relevant Data between ERP Systems and Industrial Environmental Management Information Systems Using PAS 1025 . In *Sb@ring*. Geneva, Switzerland. Retrieved from <http://www.enviroinfo2004.org/cdrom/Datas/EI2004-Exchanging%20Data.htm>.
- Zhong, Q., Qu, G., & Min, Q. (2007). An Empirical Study of Inter-Organizational Relationship in Condition of Environmental Uncertainty: from View of Information Processing Theory. *2007 International Conference on Wireless Communications, Networking and Mobile Computing*, 6209-6212.

Abbreviations

B2B	business-to-business
BA	business area
BAU	business as usual
BIS	Business Information System
BU	business unit
ECA	Environmental Costs Accounting
EMA	Environmental Management Accounting
EMIS	Environmental Management Information System
EMS	Environmental Management System
EPI	Environmental Performance Indicators
GHG	Greenhouse gases
GPS	Global Purchasing System
ICT	Information and Communication Technology
IPC	Information Processing Capability
IPM	Information Processing Model
IPN	Information Processing Needs
IS	Information System
ISO	International Organization for Standardization
IT	information technology
KPI	Key Performance Indicator
NAP	Non-Automotive Purchasing
RFI	Request for Information
UNEP	United Nations Environmental Programme
VSIB	Volvo Supplier Information Base
VSM	Viable System Model

Definitions

Business Information System	a set of business practices, procedures and processes that are implemented by computer application programs
Environmental performance	results of an organization's management of its environmental aspects (ISO, 1999)
Environmental Performance Indicator	specific expression that provides information about an organization's environmental performance (ISO, 1999)
Information System	is an integrated set of the components for collecting, storing, processing and communicating information (Encyclopedia Britannica, 2008)
Information technology	Computer-based systems, as a combination of hardware and software applications, used for the processing, storing and transporting information in digital form
IT solution	A means of providing a solution to a customer's problems using information technology (IT) (NEC, 2008)

Appendix I

Conducted interviews

Scoping / familiarization with Volvo IT

#	Name	Position	Date
1.	Lars Wemme	Manager of Process and Quality department, Volvo IT	19-05-2008 30-05-2008
2.	Magnus Holmqvist	Director of the innovation center, TechWatch, Volvo IT	23-05-2008
3.	Anders Vilhelmsson	Communication department, Volvo IT	30-05-2008
4.	Linnea Richert	Corporate environmental coordinator, Volvo IT	26-05-2008

Research interviews, semi-structured

#	Name	Position/topic	Date
1.	Morgan Ledner	Environmental coordinator of Datacenters in Gothenburg, Volvo IT	02-06-2008
2.	Annika Winberg	Line manager, Purchasing, Volvo IT	03-06-2008
3.	Cecilia Christensson	Business development, purchasing, Volvo Powertrain	04-06-2008
4.	Krister Eliasson	Sales to Order solutions, Volvo IT	05-06-2008
5.	Peter Witting	Product Development solutions, Volvo IT	09-06-2008
6.	Marko Vainio	Manager, Diagnostics tools and software downloads, Volvo IT	10-06-2008
7.	Jan Mårtenson	Purchasing solutions, Volvo IT	11-06-2008
8.	Lars-Olof Ene	Purchasing department, Volvo 3P	11-06-2008
9.	Björn Johansson	Applications for non-automotive purchasing, Volvo IT	12-06-2008
10.	Peter Blom	Travel on-line, Volvo IT	12-06-2008
11.	Claude Chanal	NetMeetings, Volvo IT	12-06-2008
12.	Christina Skoglund	Global Business Service (travels), Volvo Group	13-06-2008
13.	Anders Ahlberg	Travel application, Volvo IT	16-06-2008
14.	Lena Tingnäs-	Purchasing, Volvo 3P	17-06-2008

	Wernlund		
15.	Roger Jagefeldt	Global Purchasing System, Volvo IT	18-06-2008
16.	Stefan Boy	Diagnostics tools, Volvo Trucks	18-06-2008
17.	Lena Larsson	Business travel accounting experience, Volvo 3P	19-06-2008
18.	Stephen DeHaven	Manager Global Development Inbound, Volvo Logistics Corporation	01-07-2008
19.	Agneta Carlsson	Core values analyst, EnvCalc tool for logistics, Volvo Logistics Corporation	01-07-2008
20.	Per Dalheim	Emballage management System, Volvo Logistics Corporation	01-07-2008
21.	Lars Mårtensson	Environmental manager, Strategy department, Volvo Trucks	02-07-2008
22.	Tammo Wellemets	IT Governance, Volvo IT	04-08-2008
23.	Henrik Erkfeldt	IT solutions in logistics, Volvo Logistics Corporation	11-08-2008
24.	Cristina Nordell	Chief Information Officer, Volvo IT	12-08-2008
25.	Ingegerd Rinvall	Volvo Logistics Corporation	19-08-2008

Other meetings and events

Webcast, Volvo IT CFO and CEO, After board meeting, 19-05-2008

Workshop on ICT and environmental challenges, Copenhagen, 22 – 23 of May, 2008

IS-GDP and environmental criteria, Torsten Billing, Magnus Holmqvist, Lars Wemme 30-05-2008

Energy in Focus, meeting at Volvo Logistics, 18-06-08

Green IT conference, Milan (Italy), 25-06-08

Accounting of Business travel emissions, meeting with Global Business Service, Hylander Stephan; Hellström Annika; Skoglund Christina, 20-08-08

Appendix II

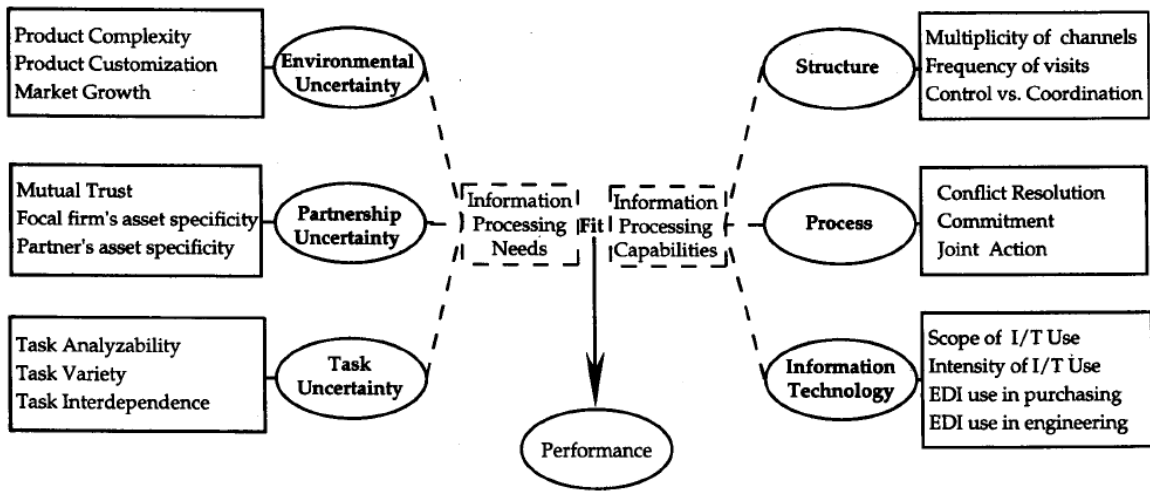
Environmental Information Matrix: Illustrating the Types of Environmental Information Flows within an Organization

General EMIS System Components	Executive Management (Managers/Directors)	Environmental management (EHS, Regulatory Affairs)	Operations (Environmental Field, On-site Professionals)
Inputs	<ul style="list-style-type: none"> - Stakeholders - Policy Makers - Other Managers - Environmental Management/Operations - Internal Reports 	<ul style="list-style-type: none"> - Best Practices - Policies, Standards Regulations - Other Departments - Internal Reports 	<ul style="list-style-type: none"> - Field Staff - Environmental Management System - Guidelines, Standards - Engineering Requirements - Internal Reports
Processes	<ul style="list-style-type: none"> - Scheduling and Planning - Internet/Intranet - Decision Support System - SAP 	<ul style="list-style-type: none"> - Environmental Audit/Risk/Impact/Assessment Systems - Materials/Waste Management Systems - Internet/Intranet - Scheduling and Planning 	<ul style="list-style-type: none"> - Compliance Audit Software - Environmental Risk Assessment - Environmental Monitoring process - Modeling and Simulation Software
Outputs	<ul style="list-style-type: none"> - Directives - Goals, Targets - Environmental Reports - Resource Allocation - Internal Reports 	<ul style="list-style-type: none"> - Environmental Management Process and Organizational Improvements - Goals, Targets - Compliance Reports - Permit Applications - Policies, Standards - Internal Reports 	<ul style="list-style-type: none"> - Process Improvements - Environmental Monitoring Reports - Compliance Reports - Internal Reports
Information Destination	<ul style="list-style-type: none"> - Other Business Units - President - Environmental Management - Other Organizations 	<ul style="list-style-type: none"> - Environmental Field Professionals - Executive - Regulatory Agencies - Other Organizations 	<ul style="list-style-type: none"> - Environmental Field Professionals - Environmental Managers - Regulatory Agencies - Other Organizations

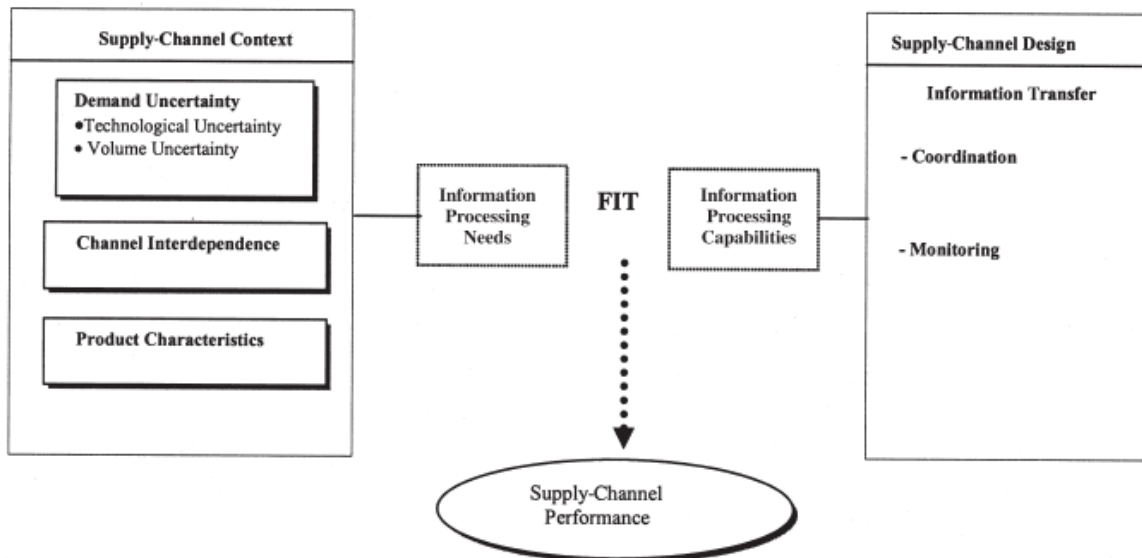
Source: Moore (2003)

Appendix III

The Information Processing Model



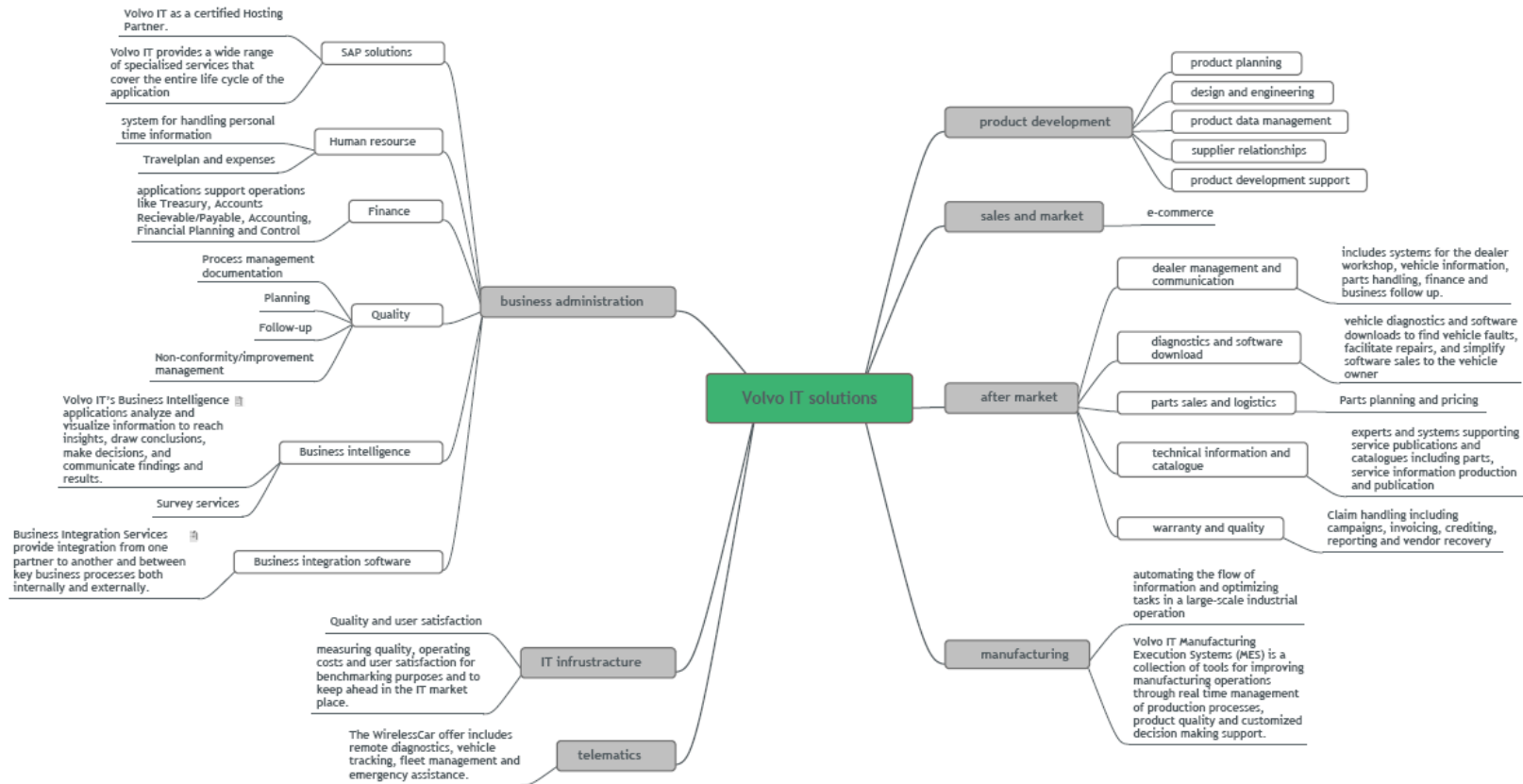
Source: (Bensaou & Venkatraman, 1995)



Source: (Kim Kyung Kyu et al., 2006)

Appendix IV

Volvo IT business solutions



Appendix V

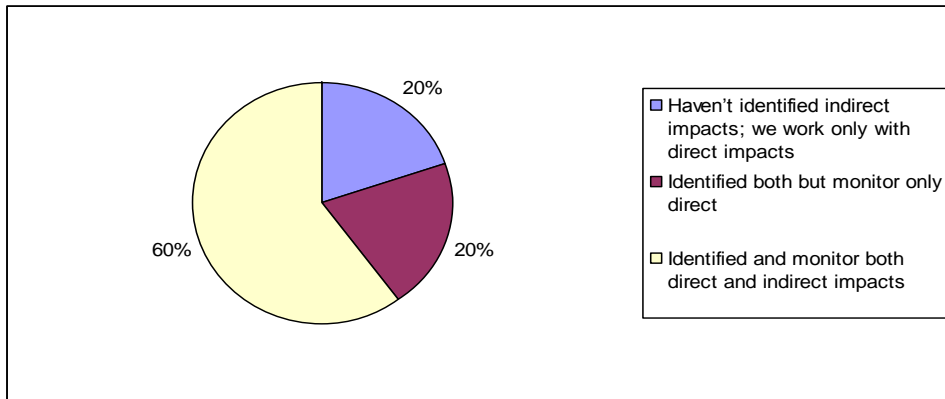
Volvo IT tools which are used in order to reduce environmental impact

Tool	Description and Environmental impact
Volvo emballage management system	System for the efficient movement of the packaging between different sites by mean of consolidation, better planning and routes optimization; helps to reduce the environmental impact from the transportation
Digital Mock-up	Simulation of the products and processes; verification and analysis of virtual test objects from different processes: from design and manufacturing till after market; reduces resources consumption necessary for the building prototypes, as well makes development process more efficient; helped saving a whole test series of S40/V50 development
Dynafleet	Software which works in conjunction with telematics solutions; helps to optimize the routes of the commercial transport; provides distant diagnostic of the vehicles; makes an analysis of the driver behavior etc; benefits: reduces fuel consumption and idling time.
Systems for the software downloads	System which allows uploading software for a number of powertrains simultaneously; reduces energy consumption necessary for the uploading as well as improves overall efficiency of the process.
EnvCalc	Calculation of the GHG emissions for various logistics routes; decision-making tool for the purchasing department of Volvo Logistics; allows identifying the most “environmentally friendly” way (mean of transport) of delivering goods.

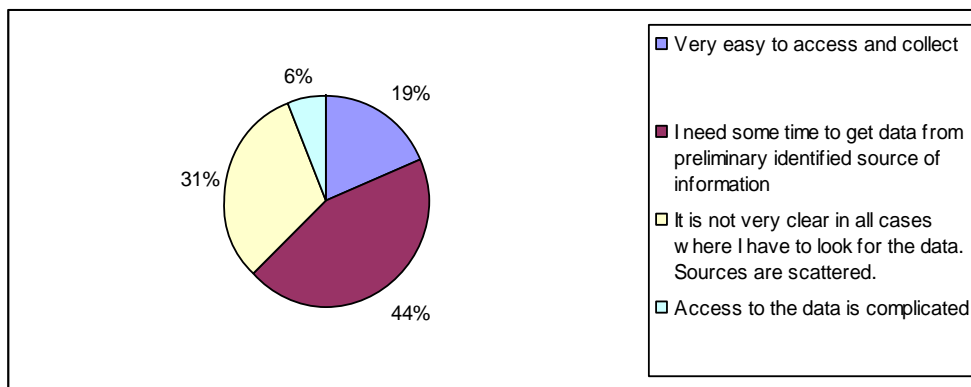
Appendix VI

Results of the survey among environmental managers in AB Volvo

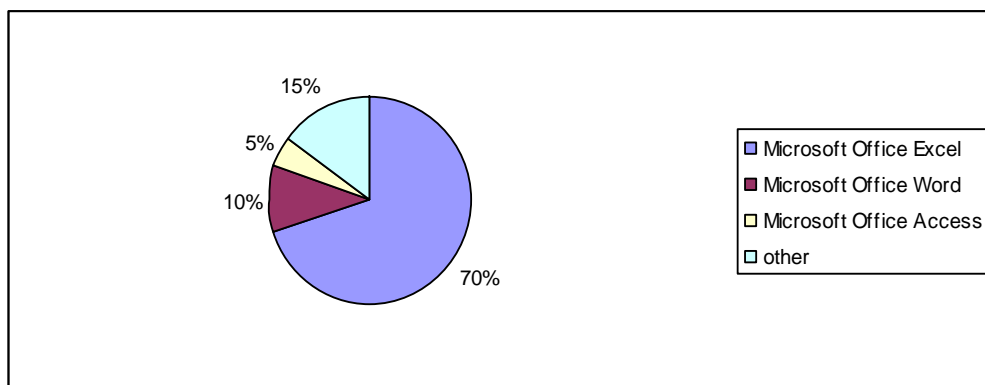
Question 1: Have you identified and do you monitor both direct and indirect environmental impacts?



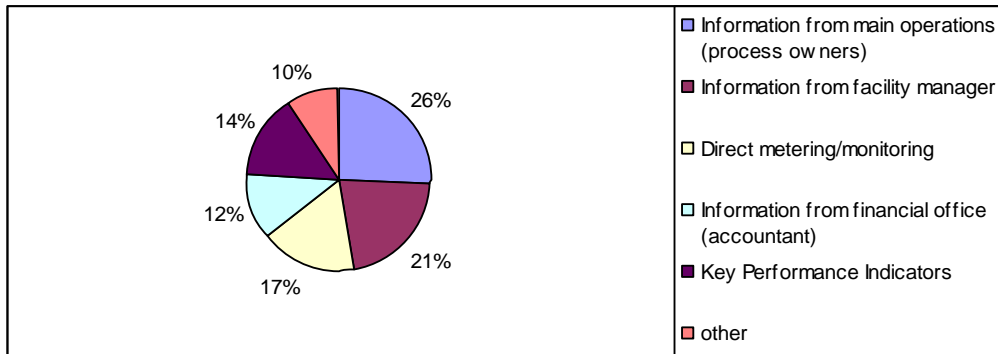
Question 2: Could you please assess the availability of the data you need for monitoring of identified significant environmental aspects?



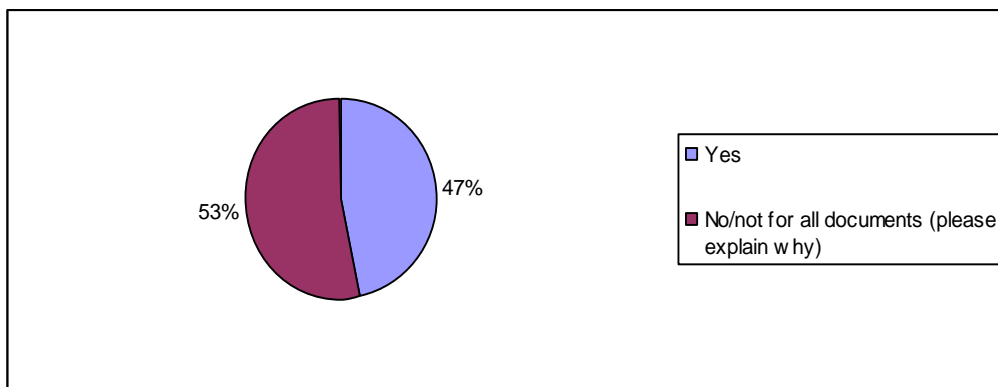
Question 3: What kind of software (application) do you use for the collecting, processing and storing of data related to the monitoring of environmental aspects?



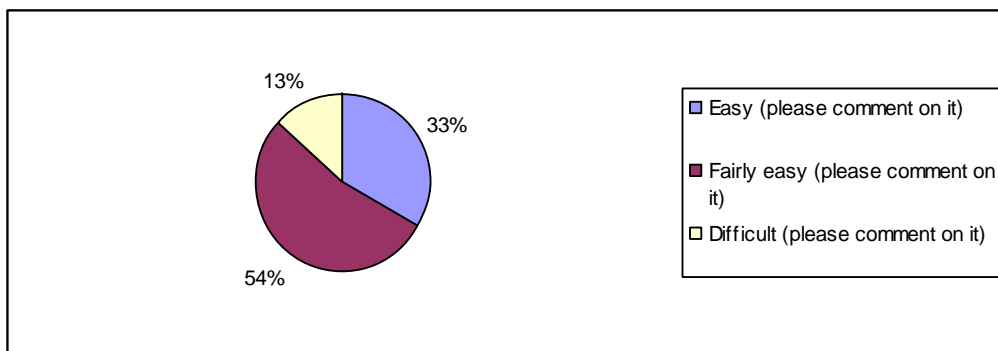
Question 4: **What are the sources of data necessary for the monitoring of significant environmental aspects?**



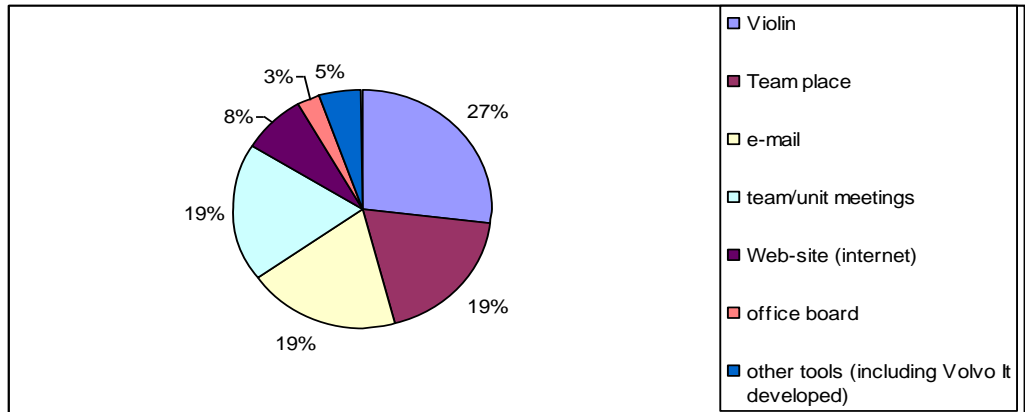
Question 5: **Are unified templates on Volvo Group level used for all documents handling in environmental management system?**



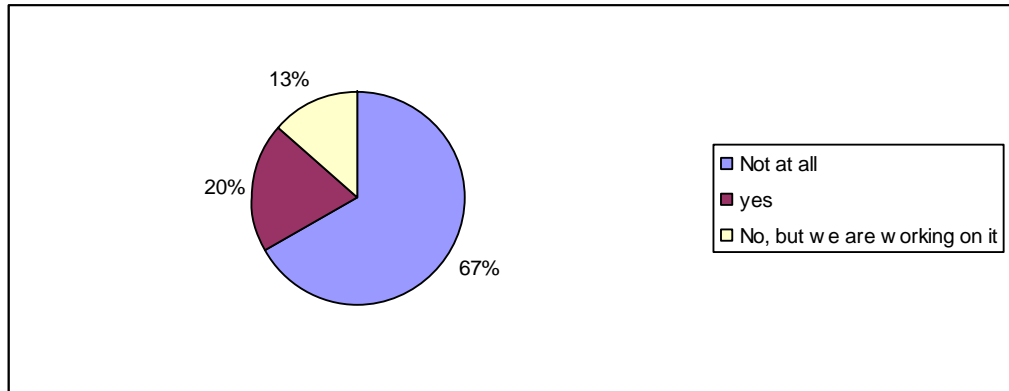
Question 6: **How do you find the process of updating the documents in the environmental management system?**



Question 7: **What are the main tools/means for the communication of work related to the environmental management system to the interested parties?**



Question 8: **Do you use e-learning tool for the training concerning environmental procedures and other issues related to the environmental awareness?**



Question 9: **According to your opinion is EMS well integrated in the IT infrastructure for the management of the core business processes?**

