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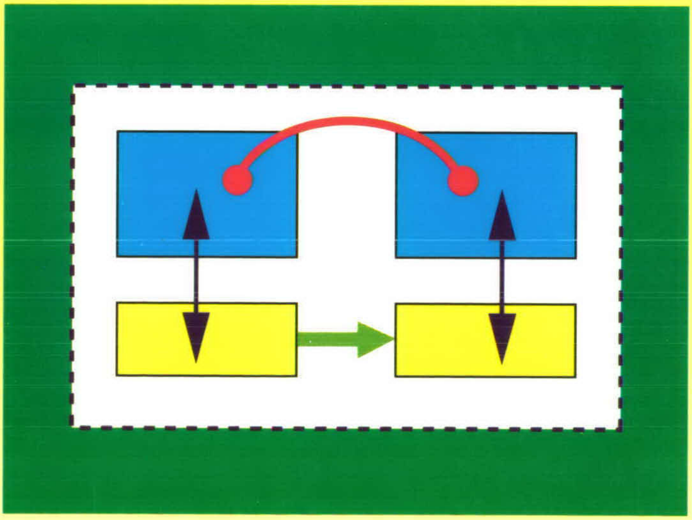
A foundation for using EDI in operational (re)design of dyadical Value Adding Partnerships

Haydee S. Sheombar



Uitgeverij Tutein Nolthenius

Coopers & Lybrand

Understanding logistics coordination

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A foundation for using EDI in operational (re)design of dyadical Value Adding Partnerships

PROEFSCHRIFT

ter verkrijging van de graad van doctor aan de
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op gezag van de rector magnificus, prof. dr. L.F.W. de Klerk,
in het openbaar te verdedigen ten overstaan van
een door het college van dekanen aangewezen commissie in
de aula van de Universiteit op
dinsdag 28 november 1995 om 14.15 uur

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Haydee Shashikala Sheombar

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Prof. dr. P.M.A. Ribbers

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Preface

The preface is the ideal place to thank those who have contributed - knowingly or unknowingly - to one's work. This is a difficult job because in the process of writing this dissertation I have absorbed and digested many ideas from peers, people in business, speakers on symposia and many authors in the literature. My thanks to all those who have shaped my thoughts and ideas. Some I want to mention in particular.

First of all I thank my supervisors Piet Ribbers and Cees Ruijgrok for their suggestions in completing the manuscript. Special thanks to Cees Ruijgrok for picking up the baton and coaching me through the crucial final lap.

Thanks to KPN Research for helping to set the direction for my research and sponsoring it. I am particular grateful to Jos Wage and Rob van der Wel whose regular feedback and suggestions have been very helpful. Their linkage to research going on within KPN Research convinced me that my endeavour was of practical relevance.

Many thanks to all of the five organizations involved in the case studies. Thanks in particular to the members of the Delta-2 project team of Sea Land Services Inc. and ECT for letting me experience what 'design coordination' is all about. Without the collaboration of these companies this dissertation would not have been possible.

Furthermore I thank my (ex)colleagues of the Erasmus University Rotterdam, Euridis, and Coopers & Lybrand Management Consultants, my MSc students (in particular Kenny Chin A Lien for his work on the simulation tool), and the members of the EDIspuut for being such an excellent forum for testing and exchanging ideas.

Embarking on the journey of writing a doctoral dissertation required some deliberation. My sister Lisa convinced me at the time that this would be a worthwhile investment and she was right. Writing this dissertation has been a greater learning experience than either of us could have imagined at the outset, and I am very grateful to her. Mandy and Jack I thank for listening to my travel stories.

My parents provided a solid basis: a wonderful childhood, a warm nest, and the comfortable feeling of being their chick for the rest of my life. I thank them for letting me flee the nest at an early age to pursue a dream thousands of kilometres away at the 'Technische

Hogeschool Delft'. Their support has not suffered from the distance nor from the international telephone tariffs. I feel this achievement is as much theirs as it is mine.

Last but not least thanks to Willie for being there, especially during the downs and disappointments, which were as much a part of the process as the ups and excitements. His support to, positive criticism on, and confidence in me have been an invaluable source of inspiration in the past and I hope these will continue to be so in the future. I wish our Value Adding Partnership lasts forever.

Haydee S. Sheombar
Schiedam, october 1995

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3. Problem elaboration and literature review

4. A theory of logistics coordination

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List of Abbreviations and Symbols

Abbreviations

BU	=	boundary uncertainty
DP	=	decoupling point
EDI	=	electronic data interchange
FGI	=	finished goods inventory
GAS	=	goods aspect system
GU	=	GAS uncertainty
IAS	=	information aspect system
ID	=	internal design
IOS	=	interorganizational information system
IT	=	information technology
ITT	=	information and telecommunications technology
IU	=	intrinsic uncertainty
IU_D	=	intrinsic demand uncertainty
IU_S	=	intrinsic supply uncertainty
LC	=	logistics centre
MAS	=	money aspect system
MLSC	=	multi level supply chain control
OU	=	organizational unit
pdf	=	probability density function
PDP	=	process decoupling point
PLS	=	production logistics system
PMC	=	product market combination
PMS	=	performance measurement system
PSL	=	process specification language
FP	=	finished product
FSM	=	finite state machine
RSE	=	reengineering support environment
SDMU	=	strategic decision making unit
SFP	=	semi finished product
SLS	=	service logistics system
TCE	=	transaction cost economics
TU	=	task uncertainty
UTR	=	uncertainty transfer ratio
VAP	=	value adding partnership

Symbols

DoF	=	degree of freedom
D_i	=	decision rule applied bu OU_i
H	=	information content
M	=	portfolio of available actions
PO	=	physical object specification, characteristic
PO_i	=	physical object specification, variable
Ψ	=	joint denotation of the environment and the GAS
T	=	time, characteristic
T_i	=	time, variable
Var(M)	=	variety in actions (M)
V_i	=	information base of OU_i
X	=	place, characteristic
X_i	=	place, variable

Chapter One

Introduction

"Nothing is permanent except change"
- **Heraclites**, ~ 500 B.C.
(in Nadler 1985)

This dissertation focuses on the operational coordination between organizations in logistics chains or networks. The purpose is to contribute to the understanding of coordination and interorganizational communication. Such understanding is the basis for reasoning about the potential of electronic data interchange (EDI) for the (re)design of boundary crossing logistics processes. In addition some practical tools and instruments are developed to support the (re)design of inter organizational logistics processes. Before stating the research problem and outlining the remainder of the manuscript, the rationale of our study is given.

1.1 Research motivation

Consider the four organizations shown in Figure 1.1, a producer, a distributor, a wholesaler, and a retailer, and the goods flow between them. This concatenation of organizations is an example of a *logistics chain*. The chain shown is a simplification because in practice each organization is part of a *network* rather than a chain of organizations. Such a network will in general also contain organizations that do not handle goods flows, e.g. banks, insurance companies, and government agencies. The term *logistics* emphasizes the importance of organizing for and managing goods flows, i.e. having the right goods, at the right place, at the right time, against the lowest possible cost.[1] Logistics should not be confused with production, warehousing, or purchasing. The aim of logistics is to manage goods flows *across* these separate functionalities. Having the

[1] With current application of logistics principles (see § 3.3) to administrative processes the term 'good' should be looked upon broadly; it also refers to other tangibles e.g. a form.

right information at the right time is critical to the successful execution of the logistics function. Therefore information processing and information exchange are important tasks within the realm of the logistics function.

Chain members that have established long term contractual relationships in order to among other things *coordinate* the goods flow between them (i.e are in a vertical alignment) are said to have formed a *value adding partnership* (VAP). In this study we focus on the coordination in *dyadical* VAPs, i.e. VAPs consisting of two organizations. For instance between the producer and distributor in Figure 1.1. We aim at providing knowledge (i.e. a theory and tools) that will contribute to the *(re)design* of the logistics processes in a dyadical VAP, with specific attention for the role of EDI as a means of communication.

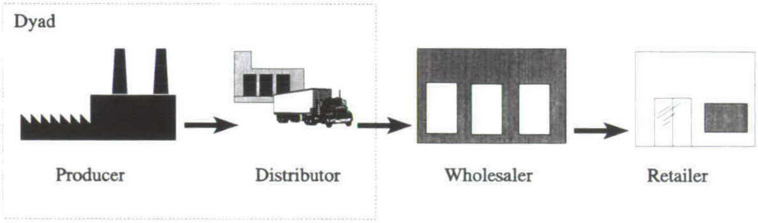

Figure 1.1 - An example of a logistics chain

Several related developments (see Figure 1.2) in the business environment drew our attention to this subject of designing logistics operations in VAPs. The first is the emergence in the corporate landscape of new interorganizational forms called hybrids, in particular VAPs. Another development is the evolution of information and telecommunications technology (ITT), in particular the spreading use of EDI. EDI is the exchange of structured messages, by electronic means, between computer applications of different organizations or organizational units. Finally, the tightening performance requirements with respect to cost and customer service drew our attention. These developments require organizations to rethink their current practice, and subsequently, if possible, design improved business processes. The significance of these developments is best summarized by Quinn (1990):

> "The ability to command and *coordinate* service activities, supplier networks, and contract relations across the globe has perhaps become the most important strategic weapon and scale economy for many of today's most successful enterprises." (our italics)

The main incentive for this research is the desire to support the business decision maker who has to transform or redesign his organization such that it has the ability to 'command and coordinate'. In Quinn's terms this ability is an encompassing one. Here the focus is confined to logistics coordination. A fundamental understanding of the subject of design is considered a prerequisite. There are many aspects to be understood in the (re)design of dyadical VAPs, e.g. the distribution of power between the constituents of the VAP, the deployment of work across the organizations in the VAP (e.g. Aertsen 1995), the dynamics of continually redesigning the operations, and legal issues in drawing up the contract. We focus on the understanding of the operational communication required to manage the goods flow between both organizations. This understanding should also allow us to reason about the merit of using EDI and the (re)design of logistics processes.

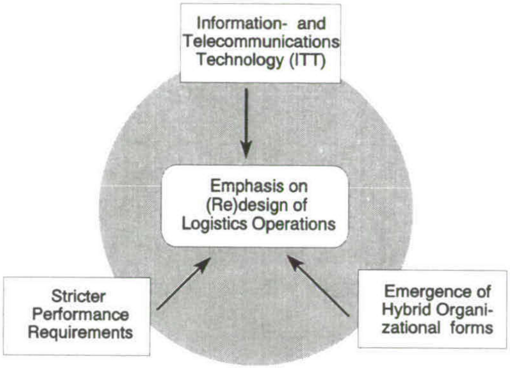

Figure 1.2 - Several developments prompted this study

1.2 The changing business environment

The developments which render our study timely and relevant (see Figure 1.2) are described next. The stricter performance requirements may be viewed as the drivers of logistics redesign. The hybrid organizational forms may be viewed as redesigning at a strategic level for improved logistics. Finally ITT can be viewed as an enabler of both of the other developments.[2] It is not our intention to explore and proof these conjectured causalities, but merely to point towards the response the developments collectively imply: (re)designing logistics operations, within and between organizations.

1.2.1 Stricter performance requirements

The current importance of logistics may be explained by a number of interrelated factors, e.g. the globalization of markets, contracting product life cycles and the subsequent shorter time to market, and last but not least, stricter environmental regulations that

[2] Bowersox (1990) observes that outsourcing has become possible only through the use of formal interorganizational information systems (secondary reference from Schary (1991)).

require strict flow control of e.g. disposables and packaging. Two major logistics performance requirements that drive logistics redesign are discussed here: *customer service*, and *cost*. Our selection of these particular measures in aligned with Sterling & Lambert's (1985, p.9) view that "cost and customer service seem to be the two most common criteria used both to design and evaluate the effectiveness of logistics systems".

Customer service. Customers grow increasingly demanding of their suppliers: they want high delivery reliability, they demand short delivery times for their purchases, and they want a broad range of products to choose from. The extreme of the latter, the increased desire for product variety, is that customers want individualized products, tailor made to their specifications. Tailor made products are not new, but the scale at which this tends to occur is. One of a kind production (Rolstadas *et al.* 1991) and mass customization (Pine *et al.* 1993) are terms coined to refer to this trend. Mass customization refers to the production design that allows for "varied and often individually customized products at the low cost of standardized, mass produced goods" (Pine *et al.* 1993, p. 108). Variety generally comes at the expense of operating cost: according to Stalk (1988, p.43) production costs per unit usually increase between 20% and 35% as the product-line variety doubles.

Cost. This brings us to the second performance requirement that calls for logistics redesign: cost. The share of logistics costs in the total cost of a product is high, and increasing due to among others the just described demand for variety which reduces productivity (see Brooke 1990). A.T. Kearney (1987) reports that in 1986 the total logistics cost averaged about 21% of the value added, opposed to 11% in 1981, showing a trend towards increasing logistics costs.[3] In some industries, e.g. food manufacturing and retailing logistics costs add up to about 37% of value added (Morehouse 1984-1985 in Coyle *et al.* 1992, p.192). From a survey carried out during 1988 and 1989 on logistics within multinational companies based in Europe, Cooper *et al.* (1991) conclude that "... there is considerable scope for improved logistics efficiency in Europe which makes it a particularly important area for management attention".

1.2.2 The emergence of hybrid organizational forms

Hybrids are described by Borys & Jemison (1989) as "organizational arrangements that use resources and/or governance structures from more than one existing organization". Examples are mergers, acquisitions, joint ventures, license agreements, and supplier arrangements. It is this latter type of hybrid that concerns us in this study, because it is for this type of hybrid that the logistics function gets boundary crossing relevance.

Although vertical integration still is a practised and advocated strategy (see e.g. Kumpe & Bolwijn 1988), there is a general trend toward vertical *dis*integration in the 1990s (see

[3] A.T. Kearney (1987) gives the following breakdown of logistics costs: transportation costs (41%), warehousing costs (21%), inventory carrying costs (23%), and administration costs (15%). These numbers of course vary over the different industry sectors and product categories.

e.g. La Londe & Cooper 1989, Broersma 1991).[4] Stuckey & White (1993) describe several forces which seem to favor this trend. Among these are the reduced costs and risks of trading as a result of an increased number of buyer and/or sellers. Also, increasing product complexity makes it difficult to maintain excellence in all areas of product development, production and product delivery. Focusing on certain aspects while purchasing from specialists suppliers and distributors may hence proof beneficial. Typical examples of make or buy decisions are (from Stuckey & White 1993, p.82):

- Should a steel plant retain all parts of its machine shop?
- Should a large exploration and mining company have its own legal department or use outside law firms?
- Should a large company have its own in-house training unit or use outside trainers?

Answering such questions may result in quasi (dis)integration solutions, in either of the many aspects on an organization, e.g. repair and maintenance, professional services, and logistics. This is called 'going back to core business' or 'focusing on core competencies'.

From a logistics viewpoint companies may contract out several parts of their business, e.g. transport, physical distribution, and parts manufacturing. In order to maintain or even improve a certain level of customer service and product quality, many companies develop close relationships with their subcontractors to manage the product flows between them. The commitments made to each other are laid down in long term contracts. These hybrids have been given many names, e.g. supplier arrangement (Borys & Jemison 1989), logistics alliances (Bowersox 1990), and co-makership (Backler 1991). The term used here, value adding partnership (VAP), is defined by Johnston & Lawrence (1988) as "a set of independent companies that work closely together to manage the flow of goods and services along the entire value-added chain".[5] ITT today enables information systems that transcend functional and organizational boundaries and allows for this 'management across the entire logistics chain'.

1.2.3 Information and telecommunications technology

The evolving information technology (IT) has several effects on the logistics function. New IT based *technologies* such as bar coding, flexible manufacturing systems, automated

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[4] Kumpe & Bolwijn's (1988) argument for vertical integration is as follows. The cost of innovation in upstream components producers is generally high and the margins are low, while profits are made downstream in businesses that are comparatively flush. In a disintegrated setting, components suppliers will not be able to compete because of their financial position, forcing downstream manufacturers to take them over, i.e. to vertically integrate. They conclude (p.81) "All in all, the tendency of many Western companies toward less vertical integration seems increasingly unrealistic". In a later publication (Bolwijn & Kumpe 1992) they reinforce their argument by showing losses in market share in upstream components by U.S. firms who adopt a disintegration strategy as opposed to Japanese firms who adopt a vertical integration strategy. As a consequence these U.S. firms may end up buying important component from their competitors.

[5] "The term *value added chain* comes from the field of microeconomics, where it is used to describe the various steps a good or service goes through from raw material to final consumption" (Johnston & Lawrence 1988, p.96). Given this description the phrase 'entire value-added chain' in Johnston & Lawrence's definition should be replaced by 'entire value added chain within the scope of the VAP'.

warehouses, robotics, automated guided vehicles all have some effect on the way organizations handle and manage their goods flow. These technologies primarily impact the separate goods related functions within an organization. IT in the form of improved *processing power* also has a profound impact on the decision making within the separate functions. For instance decision support systems for production planning and routing enhance the quality of decisions, which ultimately affects logistics performance. These are referred to by Antonelli (1988a) as the *productive features* of IT, i.e. the use of IT within production functions. We are interested in the technology that allows 'bridges' across business functions, and even across organizational boundaries. This technology, encompassing IT, is a collection of datacommunications, telecommunications, and informatics, and is referred to as information- and telecommunications technology, ITT.

As early as 1966 Felix Kaufman discussed the potential impact of 'boundary crossing data systems':

> " .. We are now witnessing the prospective developments of systems broad enough to cut across company boundaries. Obviously, such systems can have a profound impact on the way business and commerce are conducted." (Kaufman 1966, p. 141)

Today the term 'boundary crossing data system' has been replaced by inter- organizational information system (IOS) and it is generally agreed that information systems, both intra- and interorganizational, are becoming a prerequisite in modern business practice (Clemons & McFarlan 1986, Cash & Konsynski 1985). Before linking ITT to strategy some elaboration on the notion interorganizational information system (IOS), given its many forms, seems appropriate.

A classification of IOSs

The communication between organizations in a computer memory-to-memory fashion (Suomi 1990) is said to be carried out via an interorganizational information system (IOS). Instead of trying to develop a single definition for the many different types of existing IOSs (see e.g. Wierda 1991), we will give a classification of IOSs. Although some classifications of IOSs are available in the literature (e.g. Benjamin *et al.* 1990), we will develop a classification of IOS *functionalities* using criteria that enable the demarcation of the scope of this study. A particular IOS may provide more than one of these functionalities. The precise *technique* of electronic information transfer (e.g. EDI, data entry, file transfer) has no bearing on the resulting types. For each of the resulting functionalities an example is discussed in which EDI is used as the means of communication.

Three criteria are used to classify IOS functionalities.
- After Benjamin *et al.* (1990), the first criterium is the distinction between transaction oriented and non-transaction oriented systems.
- The second criterium is the relationship between the transacting parties, since the capabilities of the IOS depend on the duration of the relationship (contract).
- Finally existence of a third party is introduced to differentiate between pure markets and brokerages. Notice that this third party, the broker, should not be confused with

the *facilitator* of the IOS (see Cash & Konsynski 1985) who operates and maintains the IOS infrastructure, even though both functionalities may be performed by one actor.

Figure 1.3 shows the resulting four functionality types of IOSs which are described next.

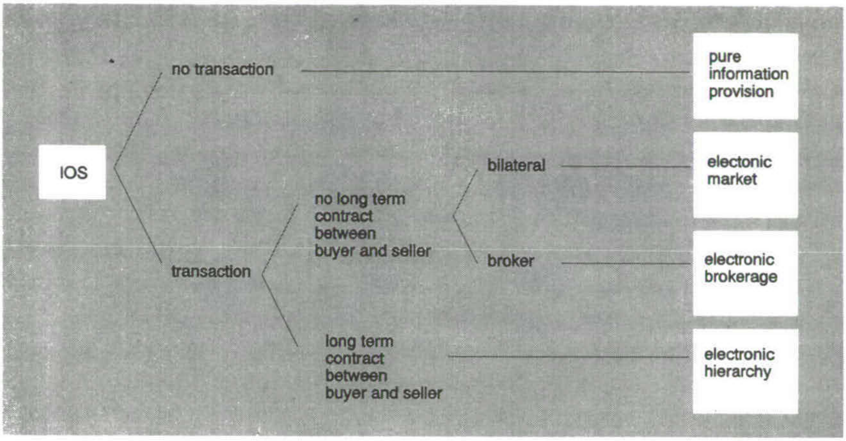

Figure 1.3 - Functionalities of interorganizational information systems

Pure information provision. IOSs in which data are stored in a central database and made available to companies, belong to the first type of IOS. No business transactions are carried out via the IOS. Examples of these systems are Nielsen marketing data and Reuter's financial information. The usual means of communication in this type of IOS is remote database access (e.g. videotex), possibly followed by file transfer. No examples of the use of EDI as a means of communication in this type of IOS are known. However, systems in which messages containing the information are directly processed by internal applications are conceivable. For instance a weekly update message on sailing schedules from an information provider to a forwarder, that automatically updates the forwarder's internal database. The forwarder would need to have a subscription to this kind of information service.

Electronic markets. In this type of IOS the transactions between buyers and sellers are structured by some business communication protocol. In case of order entry, the business communication protocol refers to the way that buyers can access the sellers' database. In case of EDI, the protocol refers to the set of standardized messages available for communication, and the scenarios for exchanging these messages. The existence of industry wide accepted standards for the messages and scenarios is a prerequisite for the viability of an electronic market system, given the wide variety of possible buyer-seller pairs. Transactions are carried out bilaterally, without a long term relationship between the two organizations. The third party in an electronic market is a facilitator who merely provides the infrastructure, and possibly maintains the standards in case of EDI, without interfering with the transactions themselves.

Electronic brokerage. In an electronic brokerage type of IOS, the transactions are carried out via an intermediate third party, the electronic broker. The function of the broker is to 'collect' supply and demand and make this information available to his clients, the buyers and sellers. Just as in the case of electronic markets, no long term relationship exists between buyers and sellers. In case of EDI as the means of communication, the message standard that is used can be determined by the broker since all transactions are conducted via this party.

Electronic hierarchy. In an electronic hierarchy the organizations involved have a long term contract or partnership and their internal processes are aligned with one another through the IOS. The infrastructure used, be it a third party network or a leased line, is not of relevance to our classification. If EDI is used as the means of communication (which is often the case), parties could decide to use proprietary message standards. Depending on the degree of process alignment, they will often do so since standardization bodies cannot (and probably should not) oversee all the (logistics) process intricacies about which two parties may wish to exchange messages.

These functionalities of IOSs are illustrated in Figure 1.4. The terms buyer and seller should be looked upon broadly. They may represent consecutive organizations in a logistics chain, while the object that is "sold" can be a product as well as a service.

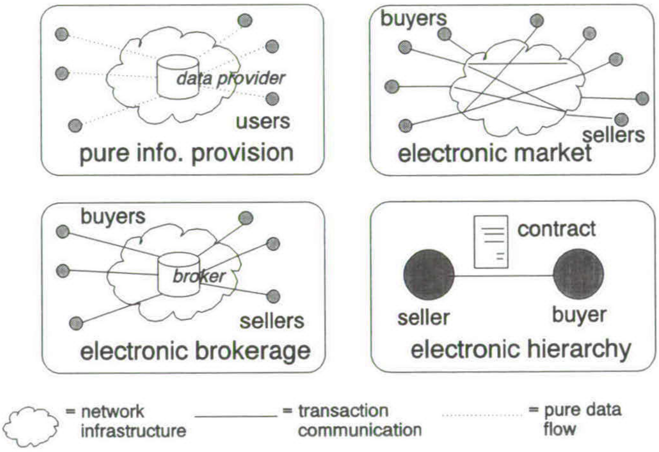

Figure 1.4 - Pictorial presentation of the functionalities of IOSs

ITT and strategic advantage

That EDI has major efficiency implications, which include cost reductions and less errors due to transcription, is today a fact beyond discussion. How much improvement in efficiency can be obtained by using EDI depends on the process at hand. In contrast to the widespread acceptance of EDI's efficiency benefits, the fact that EDI can yield competitive advantage is merely illustrated by a few popular and successful case studies in the literature. The literature suggests that lasting benefits from EDI will not be sustained by its mere implementation: "Simply providing automation of company border to company border data transport offers little real benefit to organizations" (Konsynski 1992, p.99). See also Ernst (1989) for a more general discussion of this issue. As EDI is becoming a commodity and available to all, lasting advantage can only be achieved by business redesign (Benjamin *et al.* 1990, Rose & Sharman 1989).

According to Manheim (1994) information systems that support the order cycle[6] do not create competitive advantage, but are instead a competitive necessity: "Information technology by itself is rarely a source of sustainable competitive advantage (...): most often, the knowledge of how to do something with information systems spreads rapidly, and other firms can quickly counter a firm's move" (p.73). While his main argument is that IT must be used to create and leverage the unique skills of an organization in order to yield competitive advantage, he also acknowledges the strategic potential of process redesign preceding systems implementation. As many organizations are undertaking process redesign, " (...) a key differentiating variable (...) is management capacity to lead and implement effectively" (p.70). Management's understanding of business processes and utilization of IT therein is considered a prerequisite for effective process redesign (p.91).

1.3 Business process (re)design in VAPs

The developments described in the previous section require organizations to rethink and redesign their current ways of working. Although the subject of organizational design is not new (see e.g. Galbraith 1973 & 1977, MacKenzie 1986), it is receiving renewed interest both in business and consulting (e.g. Kaplan & Murdock 1991, Rose & Sharman 1989) and in the academic community (e.g. Scott Morton 1991, Dur 1992). Most of this literature discusses the potential of IT for redesign in general, emphasizing a process orientation rather than the traditional functional orientation. Short & Venkatraman (1992) take redesign to a level beyond processes confined to a single organization, and include processes crossing organizational boundaries. This latter approach becomes more prominent as more and more organizations are focusing on their core competencies while outsourcing non-core activities.

Venkatraman (1991) distinguishes five levels of IT impact (see Figure 1.5). The bottom two levels, i.e. using IT to support a single business function, e.g. manufacturing (level 1) and to integrate existing functions (level 2), do not require fundamental changes in the current ways of working. The third level is the much discussed redesign of processes in a single organization, while the fourth level takes redesign across the boundaries of a single organization to include the entire network or chain involved to deliver a product

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[6] Manheim (1994) distinguishes three critical business processes: the order cycle, the product development cycle, and the customer relationship management cycle. The order cycle begins with the customer order and ends with the delivery of that order, including inbound logistics and production planning. We refer to the order cycle as the operational logistics processes of an organization.

or service. The fifth level has the largest strategic implications and pertains to redefining the firms mission and scope as a consequence of new IT capabilities.

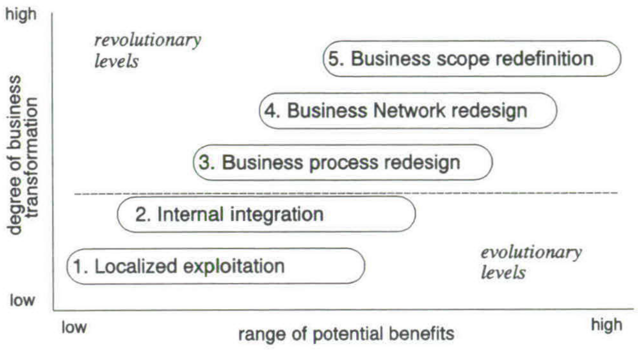

Figure 1.5 - Levels of IT induced reconfigurations
(from: Venkatraman 1991, p.127)

The literature (Hammer 1990, Davenport & Short 1990) on redesign generally stresses the importance of focusing on cross functional, customer driven, processes, instead of focusing on functional activities. Case descriptions of business redesign are given, along with phased approaches to redesign. Some researchers develop approaches and tools to support the redesign process, based on understanding of the human problem solving (see e.g. Dur 1992). In our opinion a fundamental understanding of the process to be (re)designed is the most important element in a (re)design endeavour.

EXAMPLE. Consider a producer who wishes to outsource all of its physical distribution activities, i.e. warehousing and transport (see Figure 1.1). Typical questions that the producer faces are: When is it economically attractive to contract out these activities?, Can the provider meet certain performance requirements?, What should the operational relation with the provider look like? •

These are interrelated questions, since e.g. activities will not be subcontracted if one cannot find a service provider that meets the required performance, which in turn may depend on the design of the operational relationship. Transaction cost economics (see e.g. Williamson (1985), and for this particular example, Aertsen (1995)), try to answer the first question posed in this example. Answering the second question is a matter of market search for a distributor that meets the logistics performance requirements and laying these down in a contract. These two questions, though very interesting and related to the third question, are not the primary topic of this research. The third question, concerning the operational design, may be elaborated as follows.

Assuming a certain desirable allocation of physical tasks between two organizations that form a VAP, practical issues central to the business designers of the VAP operations are,

e.g.:
- What are the joint measures of logistics performance?
- What operational procedures should govern the relationship?
- What messages should we exchange, and when?
- How time critical are the messages?
- Should we use EDI, and for which of these messages?

The performance measures are necessary to monitor and evaluate behavior of both parties during operations. The messages and procedures for their exchange establish the business communication protocol. Whether EDI should be used as opposed to other means of communications (phone, fax) depends on characteristics such as the formalizability of the message, its frequency, its error proneness. Time criticality of messages will dictate the technical infrastructure needed to carry messages, e.g a store-and-forward mailbox system with timed retrieval of messages from the mailbox, or a dedicated leased line between both parties. Such a decision will also depend on the volume of messages. In some relationships the design of the interface will include the physical interface, e.g. the height of loading docks at the producer's premises in the example described above.

The mere introduction of EDI may function as a catalyst of process improvements which would have also been possible without EDI. These improvements will often be confined to a single organization. An extra challenge to the business designer is to find redesign opportunities enabled by EDI, which involve the entire boundary crossing logistics process. Thus, in parallel to answering the questions above the redesigner should keep the following questions in mind:

- Now that we have EDI as a means of communication, what can we do differently in order to improve performance? E.g.
  (a) Are improved (re)allocations of physical and informational tasks possible?
  (b) Can the requirements on performance be tightened?
  (c) Does the contract cover the proposed (re)design or should it be renegotiated?

This is undoubtedly the hardest question of all, reason why this study aims at providing insight supporting the answering of especially the latter questions.

1.4 Problem definition

1.4.1 Research objective and problem

The *objective* of this study is to gain knowledge that will enhance the designing of the operational relationship between two organizations involved in a VAP. Although it is assumed that EDI will be used as a means of communication, many of the results of this study are not EDI specific. After organizations have searched for and found a partner, and have subsequently drawn up the contract with that partner, they need to design the operational processes, in particular their operational relationship, together with their partner (see Figure 1.6). In practice the process will not be as straightforward as depicted in this figure. For instance, the outcome of the operations design phase will often become part of the contract, which is a backward iteration. Also, ideas of how the VAP should operate will guide the search for a partner.

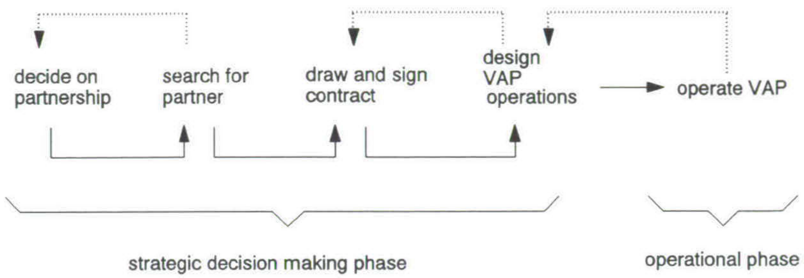

Figure 1.6 - Different phases in the VAP life cycle

The design of VAP operations is generally a time consuming (and hence expensive) process, the outcome of which is critical to the success of the VAP in the operational phase. Greater understanding of the object of design, and practical support for the process of design may therefore speed up the design process and result in better designs. From our objective we hence extract the following *problems* to be tackled by this study:

(1) develop a theory that can be used in designing VAP operations
(2) develop tools that can support this design process.

(1) The theoretical problem

At the heart of the understanding lies the assertion that 'organizations in the operational phase of a VAP communicate to coordinate'. (This assertion will be discussed in chapter four.) The theoretical problem may therefore be elaborated as:

1.1 What is coordination?
1.2 Why is it necessary?
1.3 How can it be accomplished?
1.4 What are the factors influencing it?
1.5 How may the effect of EDI on coordination enable new designs?

These questions have the signature of a theory (Weick 1989), reason why we call their collective answers 'a theory of logistics coordination'. So although our study's objective is a very practical one, the first result to be achieved is of a theoretical nature.

(2) The engineering problem

Supporting the process of designing a VAP may on the one hand speed up the process, and on the other result in better designs. A better design at the start of the operational phase will result is less need to iron out design errors during operations, which may be a very costly process since the customers of the VAP can be affected by these errors. Opposed to the understanding problem which we elaborated upon rather systematically, the elaboration of the practical design support is of a more ad hoc nature. This problem is elaborated upon as follows.

2.1 What modeling approach of logistics is appropriate?
2.2 What sub-designs can be identified in the communications part of a VAP design?[7]
2.3 How can we support the specification of the communication protocol?
2.4 What is a systematic approach to VAP design?

The modeling approach not only embeds a relevant view of reality, but also gives a language for the specification of logistics designs. Having a language for the description of our objects of design is a necessary and logical point of departure. The second question aims at finding a logical partitioning of the design (-process) for the sake of tractability. The third question aims at developing a specification formalism with which part of the result of the design endeavour, the communication protocol, can be represented. Finally, question four addresses the structure of the design process itself, i.e. the partitioning of the process into manageable and logical subprocesses, e.g. as the evaluation of alternative designs.

These questions represent our choice of relevant support issues, the choice being guided by the fact that all four subproblems deal with the design of coordination between two organizations. Others have tackled the engineering problem with problem conception convergence tools (Wierda 1991), simulation tools (Van Aalst 1992, Dur 1992), transaction (messages and data elements) specification methods (Hofman 1993), or design support systems (Mourits 1994).

1.4.2 Research demarcation

The following choices were made in order to keep this study tractable.

Operational logistics processes
First of all, only part of an organization, its operational part, is considered. Of the operational processes in an organization we limit ourselves to logistics processes. There are several operational processes (e.g. financial, commercial), and the logistics process is only one of these. This first demarcation is the same as stating that we limit ourselves to the engineering phase of the adaptive cycle.

The adaptive cycle. Business redesign is a strategic process which can best be described

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[7] In contrast to the elaboration of the first problem we prefer to speak of communication instead of coordination. Coordination is the effect of communication, and is not a tangible attribute in the design: we cannot specify it, we *can* specify communication!

by means of the adaptive cycle of Miles & Snow (1978) which is slightly adapted and presented in Figure 1.7. This strategic decision making process is a continuous organizational redesign process consisting of three phases: defining, engineering, and structuring.

- In the *defining* phase the product-market combinations (PMCs) of the organization are determined (see e.g. Abell 1980).
- The *engineering* phase deals with the design of those processes in the organization, that assure that the defined product or service reaches the defined market, within certain performance constraints. These processes will be further called the *operational processes* of the organization.
- With *structuring* we mean the allocation of tasks and responsibilities to groups within the organization, and the design of systems to ensure effective communication and integration of effort (Child 1977).

EDI can have an impact on all three determinants of an organizational design - PMC, structure, and process. In this study we focus on the impact on processes, i.e. on the engineering phase.

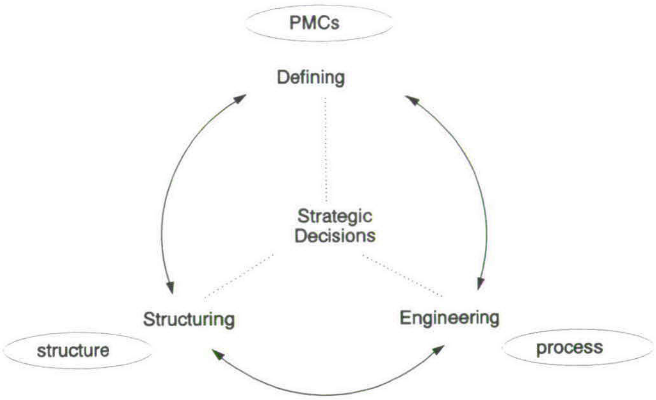

Figure 1.7 - The adaptive cycle (adapted from Miles & Snow 1978)

Dyadical VAPs

Our research focuses on business network (re)design of chains of two organizations (*dyads*), i.e. Venkatraman's fourth level (see Figure 1.5). Transformations at this level can imply transformations at lower levels. These dyads are, if they use EDI as a means of communication, electronic hierarchies (see Figure 1.3). The effect of this type of IOS functionality on the buyers' and sellers' processes is sometimes referred to as the *electronic integration effect* (Malone *et al.* 1987). This means that *virtual* integration between separate organizations can be achieved without *actual* vertical integration.

EDI as the enabler of (re)design

The final choice in this research is that the prime impetus for redesigning lies within the capabilities of ITT, in particular EDI, and not for instance in innovations in logistics equipment technology. This choice will be reflected in the strong communications/ information processing orientation of both our theoretical and engineering contributions.

1.5 Survey of the dissertation

In order to facilitate the goal oriented reading of the manuscript section 1.5.1 gives a description of the results along with their location. The logical build up of the dissertation is given in section 1.5.2.

1.5.1 Results

The results aimed for are a theory of logistics coordination theory, and tools for VAP design support. We will next elaborate on these theoretical and engineering contributions of our study.

Theoretical

In our theory (chapter four) uncertainty is identified as the cause of the need for coordination. The concept task uncertainty is introduced to represent the extent to which environmental uncertainty affects organizations. This depends on how well the organizations want to perform, i.e. on their required performance. EDI may improve coordination by enabling a further reduction of this uncertainty than is possible without EDI.

EDI induced redesigns must be searched for in directions which increase the need for coordination: the reduction of slack, or an increase of the variety in actions available to an organization. A simulation case is used to illustrate these theoretically derived directions for redesign in chapter five. In three real life cases (chapter seven) the practical applicability of the theoretical concepts and deductions are shown.

Engineering

Disturbances being events that deviate from the normal course of action, may be highly uncertain. They can only be handled by EDI to the extent that they are anticipated and their resolution can be formalized (and is considered worth the design effort). If this is not the case, disturbances need to be handled informally, which implies the existence of an informal communication channel (section 6.2) in parallel with the formal channel. The part of the design dealing with disturbances is called the 'Level C' design, while the part dealing with the normal course of action is called the 'Level B' design. As a guideline it is proposed that during the VAP design this distinction is adopted, and that these designs (levels B and C) are dealt with separately (section 6.2).

Uncertainty reduction and concurrency in logistics processes will often lead to communication intensive coordination structures. In order to assist in the design of such a rich interface a specification instrument called the interorganizational relationship (IR) state diagram (section 6.3) is proposed, along with the guideline that organizations in a VAP must assure that their views on the IR state are consistent at any point in time.

To evaluate alternative designs a modeling approach for logistics processes (section 5.1) and a simulation tool (section 5.1) were developed. Three real life VAPs which illustrate the concepts developed and which may serve as an example to future VAP designers are described in chapter seven.

1.5.2 Outline

Chapter two gives the plan of research. Our choices and intended deliverables (theoretical and practical), are explained by discussing some relevant methodological insights.

The theoretical research problem is elaborated upon in chapter three, followed by a review of some of the literature on interorganizational relationships and business process redesign. The chapter ends with the formulation of the required theoretical extensions.

This required extension is called logistics coordination theory and is presented in chapter four. We will describe and explain coordination, and make some predictions concerning the potential effect of EDI on coordination, and concerning EDI induced redesign opportunities.

These redesign opportunities are illustrated in three hypothetical case studies in chapter five. Simulation is used to compare and evaluate (redesigned) alternatives of operations in one of the cases. The modeling approach embedded in the simulation tool is presented.

Design tools and guidelines are presented in chapter six. By viewing organizations as communicating systems some useful insights are obtained through the application of two bodies of knowledge: communication theory and speech act theory.

The gap between the world of ideas which has been presented in the earlier chapters and the world of reality is bridged in the seventh chapter. Three case descriptions are given, along with an illustration of the concepts, and an assessment of (potential) EDI induced design improvements, based on the insight developed.

We conclude the dissertation in chapter eight with an evaluation of the study. Its implications for business practitioners and academia are also stated.

The following layout of the chapters of the thesis shows the contingencies among chapters and can serve as a 'road map' for reading the manuscript.

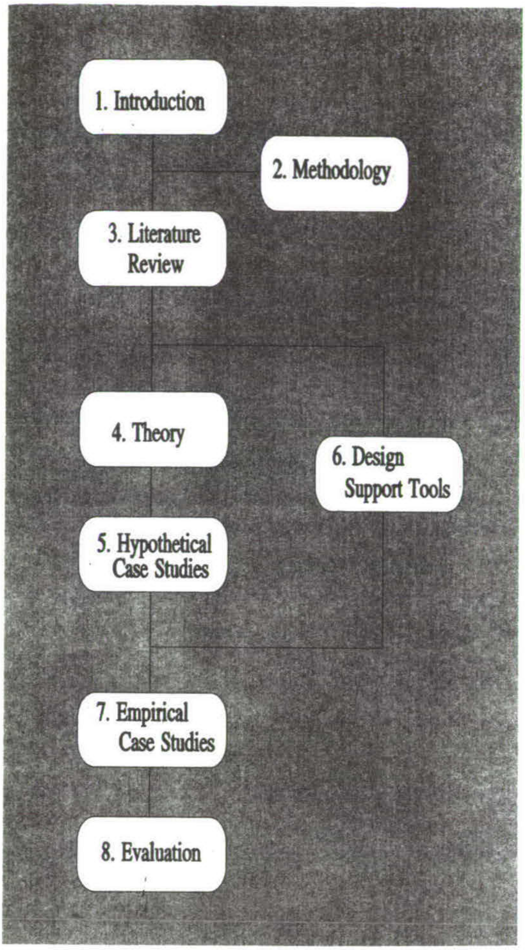

Figure 1.8 - A 'road map' of the thesis

Chapter Two

Theory, Research and Method

"Philosophy itself has no priceless results, but its study brings priceless results."
- **T. Kotarbinsky**, 1965.
(in Gasparski 1984)

In this chapter the problem stated in chapter one is linked to the remainder of the dissertation. We will do so by means of a model of organizational design. This model on the one hand guides the research and on the other hand organizes the study's deliverables. The route taken to arrive at the deliverables is explained.

2.1 A model of organizational design and this study's deliverables

The goal of our study is to gain knowledge that will lead to improved designs of boundary crossing logistics processes in value adding partnerships (VAPs). There are several routes to obtaining such design knowledge. In this chapter we will describe our route with the aid of a model of organizational design.

2.1.1 Organizational science

Organizations are part artefact and part natural systems (De Leeuw 1986). The natural or informal part of an organization evolves during its life span. The artificial part is designed by man. Once an organization is created it needs to be managed, and as environments of organizations change, organizations must change with them. Change can evolve 'naturally' or it can be accomplished consciously through intervention, i.e. (re)design. The redesigner can be the manager or a specific group of people in the organization, with or without the aid of an outside expert (business consultant). The redesigner can proceed from experience, applying design rules which were devised or stumbled on before and applied with success. Or he can look towards the organizational scientist to help him understand his design objects, an understanding which should enable him to devise better designs.

The organizational scientist may even provide rules for design, based on the understanding of the objects to be designed.[1] The researcher may also go one step further and provide tools and instruments that support the business designer in his design effort. Summarizing we may state that the tasks of organizational science are the development of:
- theories on organizations,
- rules and methods for design of organizations, and
- tools and instruments to support the design process.[2]

This portfolio of tasks coincides with De Leeuw's (1979) division of organizational science into *organizational analysis* (the development of theories) and *organizational design* or *engineering* (the development of rules, methods, tools, and instruments).

2.1.2 A model of organizational design

Building on these two faces of organizational science, a model of organizational design (the verb) is developed. This model helps to:
- position the deliverables of our study,
- explain why we have chosen these deliverables,
- clarify the coherence among the different deliverables.

Designing is "... information processing, beginning with the formulation of the design problem and ending with the solution of this problem, consistent with the actual state of knowledge and the accepted evaluation criteria" (Gasparski 1984, p. 125). Design is also an information creation process (although Gasparski's use of the term 'processing' suggests it is not, we are sure that Gasparski includes information creation).[3] As Neelamkavil (1987) and others have put it: *"design is the interaction between understanding and creation"*. In our view this understanding is embodied in two types of knowledge:
- knowledge *for* design, and

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[1] Notice the pecularity of organizational science. The 'world around us' of which the organizational scientist desires understanding is both natural and artificial, i.e. it was already designed at some previous point in time (either consciously or unconsciously; see Williamson (1990) on Bernard, p.173). Still, acquiring knowledge of the functioning of these artificial things is no less a scientific effort than acquiring understanding of the cosmos, the human body or mind, or matter.

[2] Notice that this portfolio of tasks is not exclusive to organizational science, but in fact applies to most professional disciplines, e.g. pharmacy, pedagogy, law, medicin, (technical) engineering (see Simon 1969, Gasparski 1984), since professionals are often designers. For instance the medical doctor which must have sufficient understanding of the functioning of a human body in order to design therapies to cure diseases. Engineers may provide the doctor with expert systems that support the diagnosis and design of the therapy.

[3] Koomen (1985) gives a description of the design process from an information theoretical viewpoint. He refers to the difference in information content of the output of a designer (or design system), the system design, and the input of the designer, the design specifications, as the 'noise' generated by the designer. Although the term 'noise' is merely information theoretic terminology for information output of a system that was not in the input of that system, its connotation corresponds with the creative process that generates this extra information: " .. the designer's 'noise rate' reflects the unexpected, the unpredictable, the creative act" (p.21).

- knowledge *on* design.

The knowledge for design is knowledge concerning the principles and laws that govern the behavior of the elements of a design, e.g. laws of nature, sociological laws. This knowledge alone will not be sufficient to come up with a design. Knowing all the laws of nature, e.g. gravity and material, will not be enough to design an airplane. An airplane designer will have gained in his professional training knowledge on design in order to indeed be able to design airplanes.[4] This knowledge on design will encompass three areas of concern (see also Van Aken 1994):

- what to design, i.e. what ought the structure and processes of the organization look like?
- how to design, i.e. what overall approach must be followed by the designer(s)?
- how to realize the design, i.e. what is the strategy for implementing the conceptual design?

The relationship between the two types of knowledge is depicted in Figure 2.1, along with their domains within organizational science.

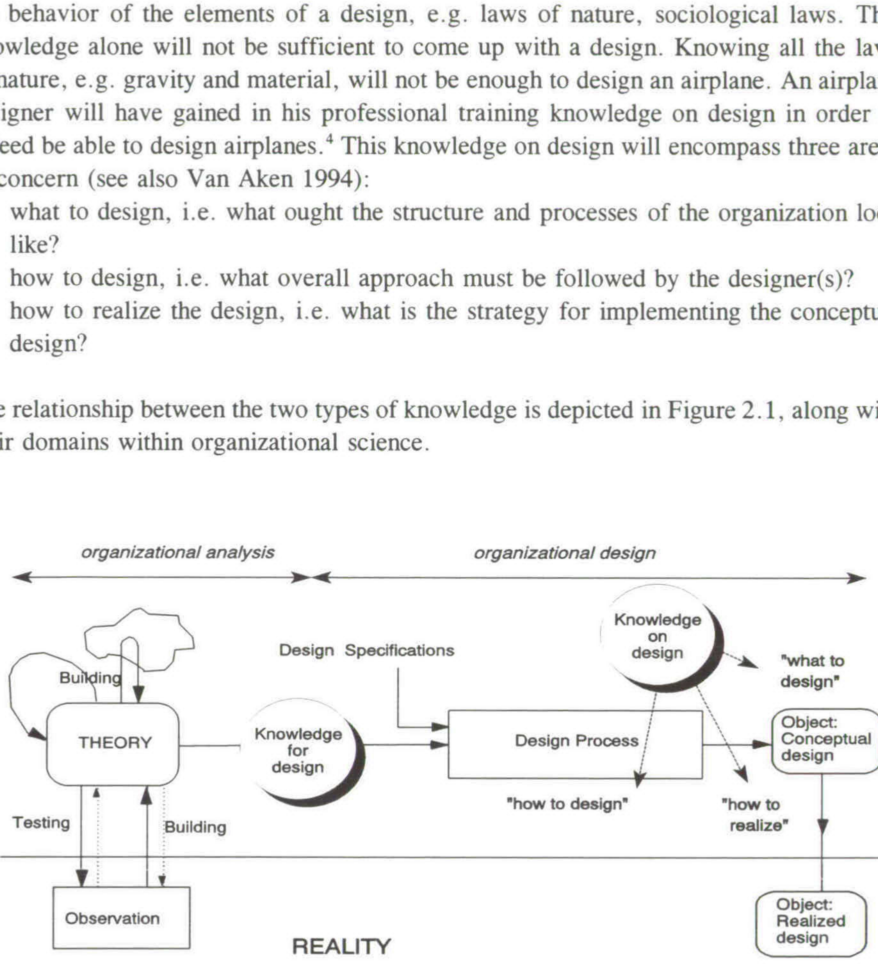

Figure 2.1 - A model of organizational design (the verb)

2.1.3 The study's deliverables

According to the model of Figure 2.1 there are a number of ways in which our goal, develop knowledge to get better designs, can be attained. At the start of the study we have *chosen* to focus on (see chapter one for our motivation):

(a) the development of a theory of logistics coordination,

[4] Example taken from Van Aken (1995), who refers to knowledge on design as design models (Du: ontwerpmodellen).

(b) the derivation from this theory of guidelines for finding improved designs.

The first deliverable is knowledge for design, the second knowledge on design pertaining to "what is designed". These two deliverables are the core of this study.

In the next section where the methods employed in obtaining and testing these results are discussed, simulation will be mentioned as a method of testing. The modeling required needed to fit the purposes of our research resulting is our third deliverable:
(c) a process view of work in organizations.

During the course of our study we encountered additional knowledge on design, which although not included in our initial research plan, we decided to elaborate upon and include in this dissertation. This because they fit within the model of Figure 2.1 and were therefore deemed relevant in light of our goal. In this sense the model has proven its use as a compass throughout the conductance of the study. These deliverables are:
(d) a tool for supporting the design of interorganizational communication,
(e) a communication model that partitions communication in several levels and keeps the design tractable.

Recognizing the diversity and multitude of deliverables we decided to develop a method for VAP redesign that brings out the coherence (their position in Figure 2.1) among the deliverables:
(f) a method for VAP design.

In Table 2.1 the rationale of the deliverables is given. In addition they are classified according to our model of organizational design.

It is reemphasized that the major deliverables are the first two entries in Table 2.1. This can also be observed from the 'road map' of the thesis at the end of chapter one, where the last three deliverables are presented in the 'side-branched' chapter six. No "how to realize" knowledge was included from our experience in the case studies. It is felt that the realization of a design in very situationally dependent. Business consultants facilitating the realization make use of a body of "how to realize" knowledge on design called *change management*, which is a field in its own right. The *process* skills of the designer are in our opinion far more important than whatever model of realization that organizational scientists may come up with.

2.1.4 Methodological note

Developing knowledge on design is trying to answer an 'ought to be' and a 'how to do ' question. Kuypers (1992) distinguishes two types of questions that may be tackled by research:
- 'ist' or 'is' questions, inquiring about the state of nature, and
- 'soll' or 'ought to be' questions, prescribing the looks of something.

The first question results in explanatory or descriptive statements, while the second question results in normative or prescriptive statements. Answering this latter type of question requires a 'principle', which is determined by either ethics, politics, or personal choice. For instance, the design of an office building in which 'comfort' is the design principle will differ from the design in which 'low cost' is the governing design principle. Both principles are equally valid, though, as long as they coincide with the intentions and objectives of the problem owner, in this case the company that ordered the building. The determination of the principle itself is hence not a scientific affair.

Table 2.1 - This study's deliverables and their rationale

Type of knowledge	Deliverable	Rationale
Knowledge for design	(a) coordination theory	Understanding of the principles of the object of design is a prerequisite in any systematic approach to design.
Knowledge on design		
"what to design"	(b) design guidelines	Takes the (abstract) theory a step in the direction of the business designer and direct/guide the (creative) effort during the design process.
"how to design"	(c) process view	For the simulation case (see § 2.2) an approach for modeling organizations was needed. This led to the process view of organization. In design in general a modelling approach or language is needed to describe the conceptual design.
	(d) communication design tool	Encountered during the case studies performed (see § 2.2). Included because it helps to handle the complexity of messages exchanged. It is applicable in every VAP design process.
	(e) communication partitioning tool	Encountered during the case studies performed (see § 2.2). Included because it helps to delineate the part of the design that deals with disturbances. This keeps the business designer focused. As disturbances occur in all real life processes this tool is widely applicable.
	(f) VAP design method	Is used to integrate the previous deliverables into a stepwise coherent approach to design.
"how to realize"	--	--

There is a difference in opinion in the scientific community whether the second type of question, the 'soll' question, belongs to the domain of science. In technical, economical and juridical sciences the second type of question is central, while in the natural sciences and sociology the first type of question is central. Simon (1969), with his "Science of the artificial" makes the case for regarding the 'soll' question a scientific one. Regardless of one's philosophical inclination, it is agreed that both questions are subject to methodology, while not necessarily the same methodology (see Nadler 1967 and Van Aken 1994 for arguments that the scientific methodology should not be applied to design).

Design questions belong to the 'ought to be' question type: given the specification of desired behavior, what ought to be the design of a system? Again, the answering should be preceded by a principle, the design principle, e.g maximize customer satisfaction. (This principle is included in the 'design specifications' in Figure 2.1). We hold the opinion that only the first type of question yields scientific knowledge, while the knowledge on design resulting from answering the second type of question should be as rigidly embedded and tested (on different criteria) as scientific knowledge. (In the annex 2.I the knowledge types are related to different types of research.)

2.2 The research design

In this section we will present the research design[5], i.e. the activities conducted in the study and the rationale for these activities. In the first chapter two problems were derived from the research objective: the development of understanding of logistical coordination (the scientific problem), and the development of practical support for the designer (the engineering problem). The outcome of our tackling of these problems is given in the previous section. Here the activities undertaken to arrive at these deliverables are discussed.

2.2.1 The research design and its rationale

Methodological position

A clear methodology for developing knowledge *on* design is lacking. Most literature on methodology is concerned with the scientific/analytical methodology, i.e. with proving the truth or refutability of an assertion. As Volberda (1992) puts it (p.11): "A methodology for developing a method is lacking". Van Aken (1994) argues that more attention within organizational sciences should be spent on developing what he calls design models (knowledge *on* design), and he proposes the clinical research approach as an appropriate methodology. The test that products of this research must withstand is not that of truth,

[5] Yin's definition of research design (Yin, 1988, p.27) as "... the logic that links the data to be collected (and the conclusions to be drawn) to the initial questions of a study" is considered too narrow: it concerns itself only with the research part of a study (which is semantically correct), while often the whole 'plan de campagne' of a study is denoted by the term, e.g. including theory building, model development, etc. Baarda & de Goede (1990) call the plan for the data collection part of a study the research plan (p.18). Van der Zwaan (1990, p.21) makes no distinction between them.

but that of workability (Van Aken 1994, p.390). Volberda (1992) advocates a synthetic research approach, which is a combination of the analytical and the clinical approach. Both knowledge for and knowledge on design are the outcome of this approach. In his opinion the outcome must withstand the test of usefulness, which is a combination of validity (including truth) and relevance.

Knowledge *for* design can be any theory that has been developed within the realm of organizational analysis (see Figure 2.1), i.e. in accordance with the scientific/analytical methodology. This knowledge is likely to have been developed for its own sake: acquiring understanding of the 'world around us'. Our theory of coordination, which is knowledge for design, is developed specifically for supporting design. Therefor, in accordance with Van Aken's position on testing knowledge on design, we are interested in whether our knowledge for design works, rather than whether it is true.[6] We favor the synthetic approach in organizational design. The deductive part of this approach is used to develop our knowledge for design, while the inductive route is used to obtain the knowledge on design. This not to say that for the latter deliverable the deductive route could not have been followed. The product of this research must be tested on its usefulness, which we define as combination of workability and relevance. As the global relevance of our effort is established in the first chapter of this dissertation we tend to use the words usefulness and workability interchangeably.

Research design

Our research design is depicted in Figure 2.2. The choices made in this design are explained:

(a) predominantly deductive road to theory development,
(b) real life case studies,
(c) hypothetical cases,
(d) the use of metaphor.

(a) Predominantly deductive road to theory development

In our opinion a researcher must have a theory to guide him through the overwhelmingly complexity of the real world. A theory will provide him with the spectacles that will help to identify what he encounters and a filter that will help to separate the relevant from the irrelevant. (In annex 2.I the classic debate between the deductive and inductive schools of thought is described.)

(b) Empirical case studies

On the other hand, especially if the purpose of the theory is to support design, understanding of the practical issues is a prerequisite. Therefor we have chosen to have two cases running with a delay in parallel with the process of theory development. These case studies serve two purposes: exploration and illustration of workability of the theory.

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[6] We here take a pragmatic position and in this respect disagree with Volberda. As long as a conceptual model or theory works for a certain class of design problems, i.e. helps to achieve good and improved designs, then its validity is not an issue as long as one does not try to apply it beyond this class of design problems.

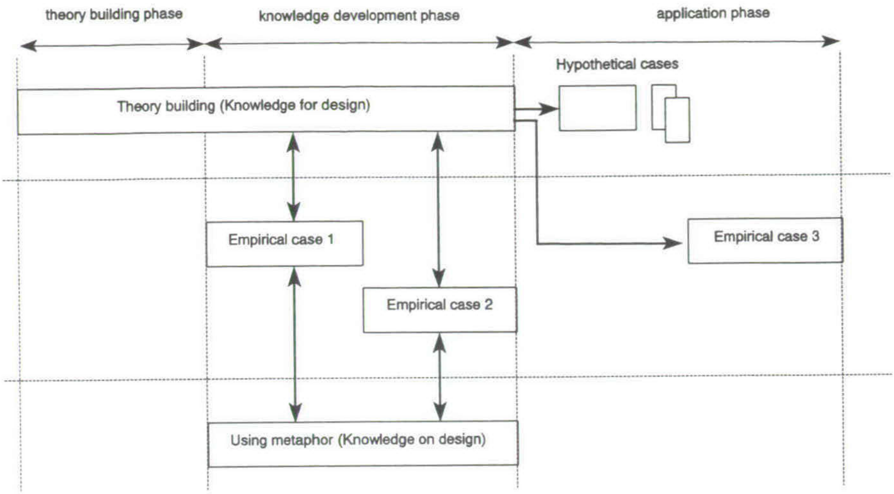

Figure 2.2 - Research design

A third case, a consultancy engagement, was used to illustrate the workability of the redesign guidelines.

(c) Hypothetical case studies

The real life cases show that the theory developed works, i.e. it helps to analyze a current design and to devise new designs in a practical setting. As our involvement in the cases did not extended into realization we have used a simulation case to quantitatively illustrate the performance improvements that can be achieved through redesign. Two other cases discuss typical solutions/redesigns that are derived from our theory and are currently of great practical relevance. The strength of using hypothetical cases is that one can focus on the point one is trying to make without getting lost in practical detail.

(d) The use of metaphor

In Table 2.1 we indicated that two of our deliverables were 'stumbled upon' during the conductance of the empirical case studies. Rather than just writing them up as do or don't rules, we felt that some embedment in the existing literature was needed. In our opinion this should apply to all knowledge on design. Just deriving from several clinical cases methods or design models, without trying to give some deeper explanation of why these work, is okay for business consultants, but not for organizational scientists. In our opinion this is where the organizational scientist adds value in the scientific field called organizational design. The added value of the business consultant is that he designs organizations 'every day'.

We will next go into some more detail for the different research activities.

2.2.2 Theory building

While there are numerous textbooks on the methodology of research, that is the *justification* of knowledge, the process of knowledge *acquisition* is not restricted by methodology. "The scientific methodology may facilitate activities that lead toward discovery, but for the present no formalized rules or logic for discovery can be explicated. Creativity, insight, imagination, and inspiration are of enormous importance in science" (Nachmias & Nachmias 1981, p.22.). Whether a theory is arrived at through "disciplined imagination" (Weick 1989) or "excursions into cloud-cuckoo land" (Stamper 1973, p.99) does not matter, as long as it can stand critical appraisal, is logically consistent, and most importantly in the case of theories for design, is useful in design practice. Testing a theory's usefulness requires the derivation of testable hypotheses or guidelines (predictions). Be aware, recalling our discussion under section 2.2.1, not to confuse testing with establishing truth. In this research we have employed all of the above approaches to theory building.

The main purpose of our theory of logistics coordination is to improve understanding, such that improved designs of VAPs may be obtained. From the theory some predictive statements, i.e. design guidelines are derived: "if you search in such and such a directions for redesign, we predict that the chance of finding a design that makes use of EDI with improved performance is high".[7]

2.2.3 Empirical case studies

The case study method is one of the various methods for conducting research in the social science discipline. Case studies can be either exploratory, descriptive, or explanatory (Yin 1988, p.15). Case study designs may be single or multiple. In studying a relatively new phenomenon such as VAPs, case studies are very useful in exploring the phenomenon, or the design process that leads to it. As explained before we have used the cases for this purpose. The emphasis in our cases though has been on the testing of the design knowledge.

Though not willing to enter the clash of methods debate, some remarks about the case method seem appropriate. Of the three 'traditional prejudices against the case study research strategy' Yin (1988, p.21) mentions, the most serious one concerns the generalizability from the limited number of cases conducted. Here we do not generalize the theory from the cases (the deductive route is traversed in this study). However we do claim on the basis of a limited number of cases that the knowledge on design developed

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[7] Theories serve two distinct goals of science: (1) prediction and (2) understanding (Dubin 1969). Understanding is defined as the knowledge of interaction of units (variables) in a system. We add as a third purpose of theory the guiding of research, especially in the deductive routes to knowledge. Some proponents of the inductive route also advocate having at least some basic models before entering the field in order not to overwhelmed by the complexity of the real world, while pure inductivists are strongly against theory guided research (see Eisenhardt 1988 on grounded theory).

works. To be correct, we must restrict our claim to the cases performed. The external validity of the knowledge will progress as the number of cases to which it is applied increases. Due to time restrictions this is beyond the scope of a single dissertation. Internal consistency and external consistency (i.e. with extant theory and practice) are additional factors that will improve credibility. This has to be build into a theory, whether one conducts a hundred cases or none.

The 'lack of rigor' and 'the time consuming and massiveness' are the other two drawbacks (prejudices according to Yin) of the case method. As to the first, of course the researcher is biased in conducting his research. We have made our bias as explicit as possible through our research demarcation and our theory. It is up to other researchers (with their biases) to try to falsify or improve the applicability of our results. As to the length and massiveness of cases, good design upfront with well-defined stopping rules, should warrant against this criticism. Especially lack of *stopping rules* may indeed take a case to the length of time, because interesting phenomenon keep popping up in the field, as has been our experience.

2.2.4 Hypothetical case studies

In the first of the hypothetical cases the theory will be illustrated on an abstract level, using computer simulation. Using simulation on the one hand gives more substance to the concepts developed, clarifying them to the reader, which can be looked upon as a purpose of simulation on its own. The main reason for using simulation in this research, however, is to build experimental settings and to illustrate the workability of certain parts of the theory. This approach for testing and applying knowledge is common in systems science, in which the computer is viewed as the systems science laboratory:

> "Indeed, the computer allows the systems scientist to perform experiments in exactly the same way other scientists do in their laboratories, although the experimental entities he deals with are *abstract constructs* (simulated on the computer) rather than specific phenomena of the real world." (Klir 1985, p.35; the italics are ours)[8]

We are aware of the fact that hypothetical cases and experiments show the workability of the theory on an abstract (though less abstract than the theory itself) level. One could argue that the external validity of these hypothetical cases is poor. We would like to argue that the external validity of the hypothetical cases and experiments is not an issue (see also Van der Zwaan 1990, pp.60-62). The purpose of the hypothetical cases is to show the

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[8] There are two main types of simulation: simulation involving human behavior (see e.g Raser *et al.* 1970, Crookall & Saunders) and computer simulation (see e.g. Pidd 1974, Shannon 1975). A simulation which involves humans as active parts of the simulation may contain computers (see e.g. Wagenaar 1992, Wrigley 1992), but these should not be confused with what is understood to be computer simulation. Simulation may have three distinctive purposes (Crookall & Saunders, p.11 ff): (1) it may serve as tool of research, as in this study; (2) it may be used as an educational aid, e.g. as a tool for creating awareness; (3) and it may be used as a professional training instrument, e.g. to train pilots, or power plant operators.

internal working, consistency of concepts, and logic of the theory. The operationalizability of concepts is another problem, something which does require real life cases.

The other two hypothetical cases are elaborate examples of redesigns. The focus is on a single aspect in each case. Practical literature in which similar redesigns were performed support the relevance of the cases.

2.2.5 The use of metaphor

Metaphor or analogy is used to explain unfamiliar phenomena in terms of familiar ones. The history of science provides many examples of the use of analogy in the construction of new theories. Nagel (1979) gives examples of the use of analogy in the natural sciences by respected scientists such as Maxwell and Kelvin. Within the organizational sciences the best known use of metaphor is probably the work of Morgan (1986) who describes eight metaphors of organizations ("organizations as ..."). Morgan argues that the strength of metaphor is that it provides understanding by highlighting a single aspect of the phenomenon under investigation. He asserts that "by using different metaphors to understand the complex and paradoxical nature of organizational life, we are able to manage and design organizations is ways that we may not have thought possible before" (p.13). In this study we will not use metaphor to develop a theory, but merely to explore practical design problems and develop tools and instruments to overcome these problems.

2.3 Concluding remarks

Nor the research design of Figure 2.2, nor the research deliverables of Table 2.1, were fully envisioned as we started out this study. What was fully crafted at the beginning was our model of organizational design of Figure 2.1. This model helped us to stay focused during the course of our study: to decide what evidence to discard and what to include. We feel that such an 'organic approach' in a new area of research, especially if one performs case studies, is very appropriate. One must be flexible enough to leave the planned path, and explore interesting and relevant side paths. In this approach a clearly defined objective, related to a model of what that objective entails (e.g. our model of organizational design), is a prerequisite for not getting lost in the labyrinth called organizational research.

The case studies (three empirical and three hypothetical) are not included in the 'deliverables table' (Table 2.1). As the design knowledge presented is not in an algorithmic form ('if-then-else' assertions), we agree with Van Aken (1994, p.397) that the case studies should be looked upon as deliverables in their own right (existential knowledge). Other researchers need the cases to evaluate the design knowledge and to make the translation to other cases.

In our research plan the activity of literature research was not mentioned, because it is a *sine qua non* for every scientific study and therefore an obvious first step. In the next chapter we take this first step. Part of the purpose of this literature review is to show the relevance of our subject matter.

Chapter Three

Problem elaboration and literature review

"..There are three ways by which human thought grows, by the formation of habits, by the violent breaking up of habits, and by the action of innumerable fortuitous variations of ideas ..."
- **C.S. Peirce,** 1892

This chapter elaborates upon the research problem and positions our study in the literature, both the theoretical and the more practical literature. It concludes with the justification for the theory to be developed in the next chapter.

3.1 Design

(Re)designing organizations, i.e. (re)designing their product-market combinations, processes and structures (see Figure 1.7), is the prime, never ending, task of strategic decision makers. Broekstra (1986) argues that organizations must continually strive for matching or realigning changes in the environment of an organization to the *internal systems*, i.e. to:

- the entrepreneurial system,
- the technological system,
- the administrative system, and
- the human resources system of the organization.

The changes in the environment which prompted our study (see chapter one) fit into Broekstra's classification of environmental changes as follows.

- *Business-structural* developments are the emphasis on customer service and cost reduction.
- The main *technological* development here is the emergence of EDI as a widespread means for business communication.
- The *administrative structural* development of importance is the emergence of hybrid governance mechanisms such as VAPs.

Environmental changes in Broekstra's *labor market and societal developments* class are not considered in our study. The external developments require adaptation of the internal systems of an organization. Of the internal systems of an organization, this study focuses on the design of the technological and administrative systems. We are hence interested in the operating principles of logistics processes and abstract from the individuals performing these processes.

Design and decision making

Design and decision making are interrelated concepts. Simon (1977 distinguishes three phases in decision making, one of which is called design. In the first phase, *intelligence*, problem situations that warrant decision making are searched for. In the second phase, *design*, alternative courses of action are devised, and tested for feasibility. Finally, in the *choice* phase, a particular course of action or design is chosen. Pritsker & Sigal (1983) define a decision as a selection of a course of action, and a decision process as a specification of the steps leading to such a selection. A decision process starts with the existence of a problem situation, and ends with the making of a decision. Pritsker & Sigal's paradigm for decision processes is given in the figure below, which also makes the comparison with Simon's phases of decision making. The arrows represent different routes that can be traversed from problem situation to decision.

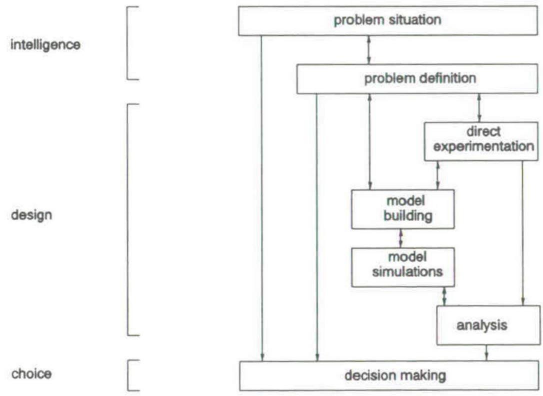

Figure 3.1 - Paradigm for decision processes (Pritsker & Sigal 1983) compared to Simon's (1977) phases in decision making

More complex problems often cannot be solved directly (the route from problem situation or definition to decision making), but actually require a design phase. As direct experimentation is generally not desirable in business, the route of model building, model simulation, and analysis is advocated. Simulation is a way of evaluating alternative designs and choosing a satisfactory (not optimal!) design. Elements needed in using simulation in the design process are depicted below.

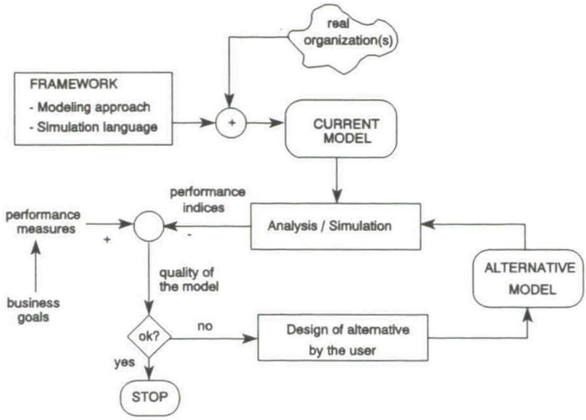

Figure 3.2 - Elements of using simulation in organization design

Notice that the framework of Figure 3.2 comprises both a *modeling approach* and a *(simulation) language* for specifying the model. The framework is used to map "... a practical situation so that it becomes a basis for subsequent manipulations" (Gasparski 1984, p.85-86). The mapped situation is expressed in a language which is called the design language.[1] In our case this corresponds to an executable programming language, called PSL (process specification language). Only the characteristics considered essential are mapped. In chapter five we discuss our 'essential mapping'. Having a design language available at the beginning of a design endeavour, alleviates the need to develop one during design. Since a design language embodies information i.e. the essential mapping, less information needs to be created during the design process (see Koomen 1985, p.24). This may positively influence the duration (thus cost) of the design process.

Design and Redesign. Although merely intuitive, and nowhere sharply defined, the verb 'design' refers to designing something from scratch, while the verb 'redesign' refers to alteration of an already existing design. Most of the literature on the IT capabilities for organizations use the terms 'reengineering' or 'redesign' instead of 'engineering' or 'design', to refer to the already existing organization (design). Gasparski (1984, p.122 ff) distinguishes two methodological approaches. The first, called the *improvement approach*, analyzes the existing state (design) and adds incremental improvements until the limit of improvement is reached (see Figure 3.3.a). The second approach, called the *design approach*, totally disregards the current state (design) but starts with finding an ideal design, and then develops a model for realizing this design. If the model of realization is acceptable, the ideal design is implemented. If not, the ideals of the ideal design are lowered, and its realizability is reassessed. This process iterates until a realizable design is found (see Figure 3.3.b).

[1] Wierda (1991, p.32) refers to such a language as the *vocabulary* for describing the problem situation in detail, a description which he calls the 'conceptual model'. The 'specification' of the conceptual model is called the empirical model, which can be used to generate and analyze solutions (p.31). With *specification* Wierda (p.124) means the instantiation of the conceptual model.

In business redesign the improvement approach seems the logical choice, as radical change tends to evoke resistance. However, we like to argue that such an approach leads designers along conventional roads of thinking. Whereas the design approach does not at first hinder the designer with the current state, but let his creativity take charge. A drawback of this approach might be that the radically new design will not be accepted by the people in the organization who are part of the design. We would advocate the design approach, with continuous participation of the people that will be part of the new design, in order to reduce the resistance to change.

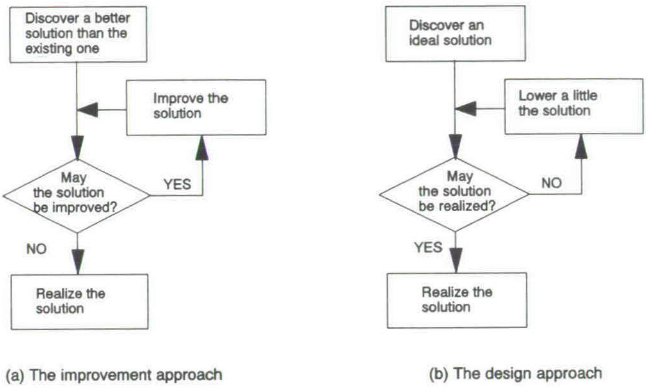

Figure 3.3 - Two methodological approaches to redesign
(from: Gasparski 1984, p.123)

Several routes to design

We aim at developing understanding that supports (re)design of the logistics processes. This understanding will take the form of a theory of logistics coordination, and should in our opinion ideally precede the design of logistics processes. There are many routes to design, or put alternatively, many types of knowledge that support the design process. Bosman (1986) has identified different classes of models which may be used as the basis for a design. He distinguishes between conceptual (or data void) and empirical models, and between descriptive and prescriptive models, resulting in four classes of models (see Figure 3.4). The descriptive part of a theory coincides with a conceptual descriptive model.

Empirical descriptive models are models of the ultimate design, hence containing data about that design, e.g. the level of capacity, which may be used to experiment with during the design process. Simulation models are examples of empirical descriptive models. Assuming that every description of something must have some rationale or underlying theory, models in class (4) must ideally be preceded by models in class (2). This is often not the case[2].

Conceptual descriptive models (2) are theories that explain parts of reality relevant to the object to be designed, e.g. the environment is which the design is to function, or the 'material' of which the design is composed. Although the route from conceptual descriptive models to design, route d, is not as straightforward as in the routes from the other classes and comprises a lot of creativity, we agree with Bosman that this class of models is probably the largest contributor to design, especially in organizations.

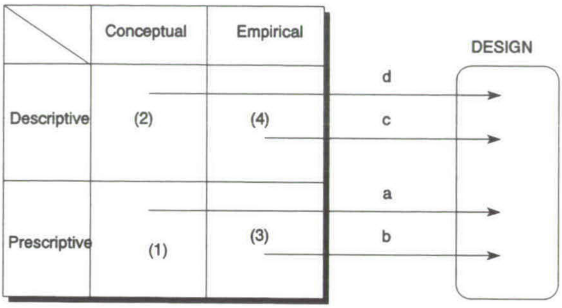

Figure 3.4 - Four routes a,b,c,d from models/theories to designs (Bosman 1986)

Conceptual prescriptive models refer to methods to be used to solve a design problem. We have referred to these models as knowledge on design in chapter two. Empirical prescriptive models are applications of the methods of class (1) to a particular design problem. In themselves they do not contribute to the design process, but merely check whether the method chosen complies with reality. Not all conceptual prescriptive models can be translated into empirical prescriptive models, especially in organizational science.

We aim to develop knowledge for design, i.e. a class (2) model. Additionally some guidelines are given, which fit Bosman's class (1). In this chapter we will demarcate our object of study by introducing some concepts (§ 3.2), and give a brief description of our object of design, logistics processes (in § 3.3). We will then survey some of the practical literature on (re)design and on class (2) knowledge on organizational relationships (§ 3.4). Class (2) knowledge on coordination is reviewed in § 3.5. We will evaluate our findings in § 3.6 and conclude that the class (2) knowledge available is not sufficient and justify the need for the theory presented in chapter four. In chapter five a simulation tool by means of which one can arrive at designs of logistics processes, class (4) models, is introduced.

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[2] Not all modeling approaches (see e.g. Dur 1992, Streng 1993) obey this methodological requirement. In our opinion this is not a drawback since, the quality of a class (4) model is determined by the efficiency and effectiveness with which it supports the design process, regardless of the existence of an underlying theory (class (2) model).

3.2 Concepts

In chapter one we delimited the scope of our study to operational logistics processes in dyads. The concepts introduced in this section give a more precise delineation of the subject matter of this dissertation. The object of study is operational logistics coordination between organizational units (OUs) which form a dyadical VAP. Some clarification of all three concepts, *organizational unit*, *dyadical VAP*, and *operational coordination* is warranted.

3.2.1 An organizational model

A view of organizations is needed that allows for positioning our study, and serves as a basis for further description and theory development. Our model of organization consist of two parts (see Figure 3.5):

- a strategic decision making unit (SDMU), and
- an operational or organizational unit (OU).

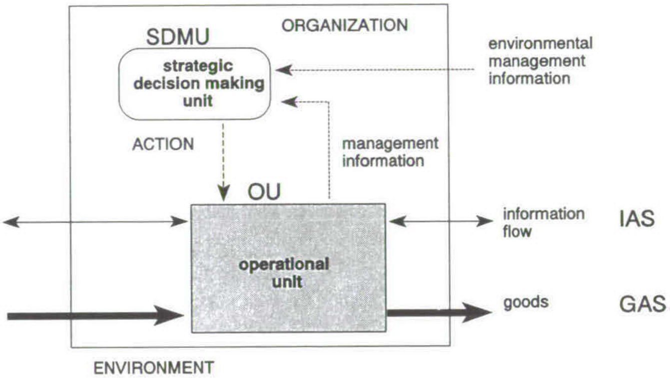

Figure 3.5 - The organizational model

Large organizations comprised of relatively independent business units and/or departments will be modelled with more than one OU. The criterium for departments to be modelled as separate OUs is that *operationally* no hierarchical referral (or authority) is used to control interactions between OUs. The SDMU makes decisions pertaining to the design of the OU, while the OU merely represents the operating core, i.e. the day to day operations, of the organization. The SDMU determines the long term strategy of the organization, basing its decisions on environmental monitoring and scanning as well as on management information (feedback) on the performance of the OU. The implementation of these strategic decisions is reflected by the arrow labelled "action" in Figure 3.5, which boils down to (re)designing of the OU.

This model represents an organization as a *multilayer system* (Mesarovic *et al.* 1970), which is a system in which the time horizons of the layers (the SDMU and the OU) are different. The essence of this model, however, is not so much the difference in time horizons, but the fact that the SDMU and the redesigners therein design the OU, while the OU makes decisions necessary to perform the designed operations (to keep them "up and running"). The rationale behind this model is thus the sharp distinction between design and operations, and within operations (the OU) the selection of the logistics processes.

There are several processes in the OU, such as human resource management processes, financial processes, and operational sales processes. We focus on the logistics processes. Application of the systems approach (see in 't Veld 1988 for the terminology used here) to a network of OUs, yields the following essential aspect systems (see Figure 3.6) for a logistics process: the *information aspect system* (IAS) and the *goods aspect system* (GAS). Figure 3.6.b shows the aspect systems at the OU level of abstraction.

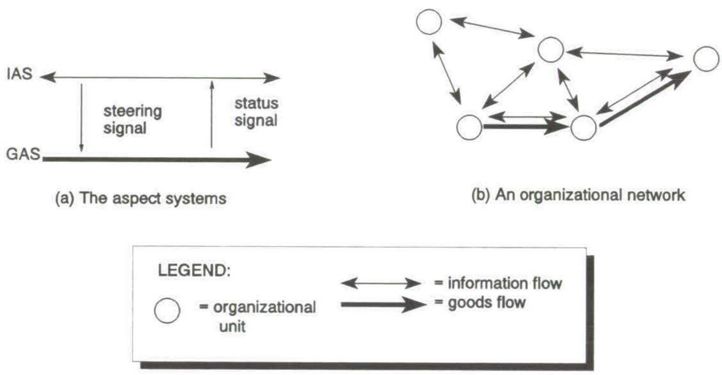

Figure 3.6 - The systems approach

Relations between aspect systems are called *interrelations*, while relations between system elements at the OU level of abstraction are called *inter organizational relationships* (IRs). Even though the money aspect system (MAS) is an integral part of an OU and is important in some logistics processes (e.g. the letter of credit in international trade), it is beyond the scope our study, since most logistics processes primarily exist within the IAS and GAS (see e.g Ernst 1989). Interrelations between the IAS and GAS are called *steering* - (IAS to GAS) and *status signals* (GAS to IAS). Interrelations between aspect systems are not apparent at the actor level. This is an important statement because it implies that one organization generally cannot directly steer the GAS or directly obtain status information on the GAS of another organizational unit.

3.2.2 A dyadical VAP

A dyadical VAP is an organizational form positioned between two completely separate organizations and a single vertically integrated organization on the market - hierarchy continuum. An organization is called vertically integrated when it encompasses several adjacent links or activities in the logistics chain, or as defined more precisely by Adelman (1949): "A firm is called vertically integrated when it transmits from one of its departments to another, a good or service which could, without major adaptation, have been sold in the market"[3]. Notice that these activities may be really integrated into one OU, but they may very well be relatively independent parts of the organization in which case they are modelled as separate OUs (which may use EDI for communication). Between the single vertically integrated organization and two completely separate organizations lies and entire spectrum of organizations which have an inter organizational relationship.

Inter organizational relationship. When the interaction between two OUs is durable, and the OUs are not subsystems of the same hierarchy (in the economic sense, see Williamson 1985), we say that there exists an inter organizational relationship (IR) between the OUs. Thus OUs which perform their transactions through a (pure) market do not have an IR, nor do OUs of which the transactions are controlled hierarchically by a third unit in the same organization. Van de Ven & Ferry (1980) state that " .. an IR occurs when two or more organizations *transact resources* of any kind (money, physical facilities and materials, customer or client referrals, technical staff services). An IR can be very temporary with a one-time resource transaction, or longlasting with ongoing exchanges over time."

From their definition it can be observed that they consider one-time transactions conducted in the market, also IRs. Such a short lived relation between a buyer and a seller will not be considered an IR in this study, and is of an entirely different nature than the longlasting relationship which we call an IR. Apart from the exclusion of this type of market transaction, our definition coincides with Van de Ven & Ferry's. We therefore define an IR as follows.

> *An IR is the relationship between two or more organizations that transact resources of any kind, on the basis of a long term contract, with ongoing transactions over time.*

Interorganizational arrangements in the literature. The growing interest of both business practitioners and academics in IRs is reflected in the fast amount of literature on the topic. Lodge & Walton (1989) advocate that American corporations, in order to stay competitive, should develop relationships among competitors, between suppliers and customers, and even between industry and government. Most of the literature focuses on the first two types of partnerships, which are referred to as horizontal and vertical respectively. Powell (1990), Luke *et al.* (1989), and Borys & Jemison (1989) for instance discuss inter organizational relationships in general. Jorde & Teece (1989) predominantly discuss strategic alliances of the horizontal type, e.g. joint research and development in

[3] Adelman, M.A., "Integration and antitrust policy", *Harvard Law Review*, Vol. 63, 1949, nr.1; secondary reference from van Hulst & Willems (1989).

high-technology industries. The majority of the literature focuses on vertical inter organizational relationships, e.g. Backler (1991), Normann & Ramirez (1993), Cunningham & Tynan (1993), Larson (1992), Mitchell *et al.* (1992), and Provnan & Skinner (1989). Relationships, whether horizontal or vertical, can pertain to product development, product delivery, and customer service & management (Rockart & Short 1989). Apart from these more or less durable interorganizational relationships, Miles (1989) discusses the dynamic network organization, which is a connection of several firms with distinct roles.[4] The firms may be hooked up together for perhaps only one product "event", hence the term 'dynamic'.[5] This dynamic form of a network is also discussed by Vervest (1994). According to Antonelli (1988b) network firms (not necessarily dynamic) typically consist of units/firms that are large in governance (i.e. coordination) and small in production. This brief review of the literature not only suggests a wide diversity in relationships, but also a wide variety in terms connoting the same type of relationship, which is a problem typical for new fields of interest. Our research focuses on value adding partnerships which in terms of the preceding review can be typified as: vertical, pertaining to product delivery, and durable.

Value adding partnership (VAP). The term VAP has been introduced by Johnston & Lawrence (1988) and is defined as

> *"a set of independent companies that work closely together to manage the flow of goods and services along the entire value-added chain".*

Thus a VAP is a type of IR in which the OUs involved belong to adjacent stages of the logistics chain. E.g. an organization has an IR (not a VAP) if it has a purchase contract with a supplier. If the two organizations have also agreed on procedures on how the goods are delivered and have additional contract governed communication in this respect the organizations are said to form a VAP. In this research we focus on these logistics alliances along the logistics chain between two organizations, and from here on the terms VAP and IR will be used interchangeably.

Transaction. The Longman dictionary of contemporary English (1978) defines a transaction as the act of carrying (a piece of business, matter, etc.) through to an agreement. Baligh (1986) states that "Two persons are ordered by the transaction, or the exchange of goods or services, between them. The transaction is defined in terms of the control that each transactor loses and gets over specific elements on his environment. One

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[4] Miles (1989) distinguishes the following roles that are connected in networks: designers, suppliers, producers, distributors, and brokers. He states that in a fast-moving economy the brokering role (or coordinating role) is becoming increasingly important.

[5] A striking, illustrative and comprehensive example of highly dynamic networks can be found in the motion picture industries. Once (not more than 35 years ago) it was a highly integrated industry. "Today, movies are made by "independent producers, directors, actors, and crews, using leased space and equipment. A movie may be shot in China, dubbed in London, and edited in Berkeley". (Miles 1989, p.18).

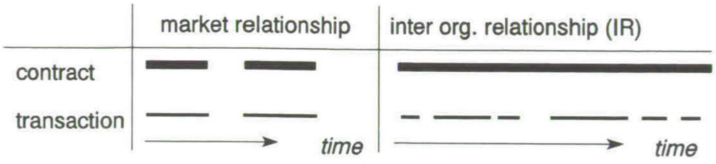

Figure 3.7 - Contract and transaction as definers of relationships

gives up control over ten dollars, the other gives up control over a pair of gloves." Williamson (1985, p.1) defines a transaction as follows: "a transaction occurs when a good or service is transferred across a technologically separable interface. It appears that no single definition of transaction is acceptable for all purposes. For our purpose we describe a transaction as comprising all the exchanges between OUs (in both aspect systems) necessary to carry over a "piece of business", in our case goods or services, from one OU to another. A transaction comprises at least an order-message (or something with the same connotation) from one OU to the other.[6] Transactions are always governed by a contract. In case of a market relationship the duration of the contract and the transaction is the same. When two organizations are involved in an IR, the duration of the contract between them is longer that the duration of individual transactions (see Figure 3.7).

3.2.3 Coordination

Coordination refers to the effort directed at making two OUs perform as though they were integrated. A coordination mechanism is the way in which coordination is achieved. A precise definition of coordination and the derivation of aspects of coordination are deferred to chapter four.

Operational and design coordination. The development of a VAP was presented schematically in Figure 1.6. One needs to distinguish coordination in the design phase of a VAP from coordination in the operational phase (see Figure 3.8). The *design coordination* takes the form of meetings among representatives of the SDMUs of both organizations during which the contract is detailed out; messages, shared performance requirements, and procedures are agreed upon; and conflicts between both organizations are resolved. The output of this design phase is a *blueprint* specifying among others how the VAP will be coordinated operationally. Hence the designers who are working at the strategic level must have an understanding of how things work operationally. Of this operational coordination it is aimed to unravel the central ideas. The interesting and very relevant issues of design coordination, e.g. negotiation processes, interaction between the members of the design group and their respective organizations, are beyond the scope of this study.

[6] See chapter six for a classification of messages.

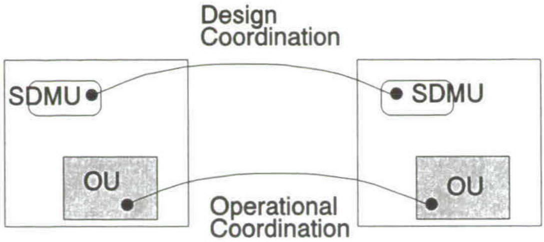

Figure 3.8 - Design and Operational Coordination

Within the literature on intra organizational coordination Thompson (1967) distinguishes the following mechanisms for coordination[7]:

- *coordination by plan*, in which all interaction is governed by a predetermined plan and no additional communication is needed;
- *standardization of process*, in which the way to interact is standardized in terms of predetermined rules and procedures; communication is required, since events to which parties must respond are unknown upfront and their occurrence is not visible to all parties (e.g. OUs);
- *mutual adjustment*, in which interaction is determined in an ad hoc manner for each occurring event that requires a coordinated response.

In a VAP the operational coordination mechanism is predominantly of the standardization of process type, i.e. the blueprint coming out of the design phase contains the procedures and rules which will govern the operational coordination. The effort (hence cost) made during the design phase of the VAP is earned back by having a fairly standardized operational phase. Only a small part of the interaction in a VAP will be governed by mutual adjustment. Coordination by plan may be used for certain periods during operations, the plan however being determined operationally over and over again by the predetermined procedures and rules. Completely planned coordination of VAP operations is generally not possible since the environment in which the VAP operates is dynamic, e.g. customer demand is uncertain and varies over time. These dynamics of the environment of a VAP are referred to as the *first order dynamics*, and the blueprint is designed to cope with them. If the changes in the environment are of such magnitude that the blueprint no longer works, it (i.e. the design) needs to be modified. These changes, referred to as *second order dynamics*, may even result in a dissolution of the VAP.

[7] The coordination mechanisms as they are described by two more contemporary authors on the subject, Galbraith (1977) and Mintzberg (1979) are discussed in section 3.5.

3.3 Logistics

A brief description of the object of design, logistics, is appropriate. Only some essential notions are introduced and the interested reader is referred to the numerous textbooks on the subject (e.g. Bowersox 1986, Christopher 1984, Coyle *et al.* 1992, Magee 1985). An introduction to logistics, a classification of logistics systems, and a framework for logistics performance measures are given.

3.3.1 Introduction

Logistics can loosely be described as the planning and control of goods flows. Hutchinson (1987) defines logistics as "The process of having the right quantity of the right item in the right place at the right time"[8]. We would like to add to this definition "at the lowest cost". Daskin (1985) defines logistics management as "the design and operation of physical, managerial and informational systems to allow goods to overcome space and time". Ruijgrok (1991) emphasizes the design task of (integral) logistics management by defining it as the choice among alternative designs, i.e. what activities are performed where, how, and when, which is based on a consideration of the trade-off between all aspects relevant in a particular situation, e.g. customer service and efficiency. We define of a logistics process as follows.

> *A logistics process is that process comprising all activities that plan, control, and perform the flow of goods and resources within and between organizations.*

Logistics management deals with the integral control of the entire goods flow through an organization. Within the literature (e.g. van Goor 1987) the distinction is made between *materials management*, which is the management of the goods flow to and within production, and *physical distribution management*, which is the management of the goods flow to the customer (see Figure 3.9).

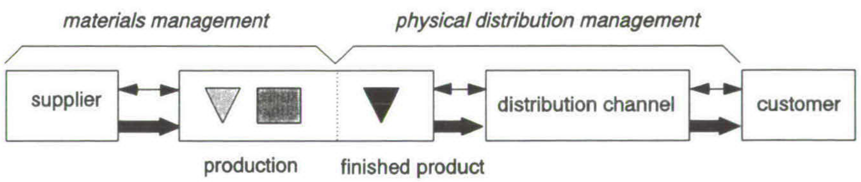

Figure 3.9 - Logistics management

We next state the logistics objectives and postpone the assessment of logistics performance measures to subsection 3.3.3.

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[8] Secondary reference from van Aalst (1992), p.177.

The objective of logistics management is determining and attaining a prescribed level of customer service while minimizing logistics cost.

An important concept in logistics system design is the *decoupling point* (DP) or order penetration point (see Rose & Sharman 1989). The DP separates the 'on customer order based' activities from the 'on forecast based' activities in the logistics operations of an OU (see Hoekstra & Romme 1987). The DP is the storage point of goods (inventory) after which all activities are customer order specific. The location of the DP is primarily determined by the delivery time required by the customer and the process lead times. Other factors that determine the location of the DP are e.g. the specificity of products and the cost of obsolescence (both pushing the DP upstream). Deciding on the location of the DP is an entrepreneurial decision in which the risk of not being able to fulfil a customer's requirements is weighed against the risk of investing in downstream stock (Hoekstra & Romme 1987, p.23).

The DP is one type of the more generic *process decoupling point* (PDP). A PDP is a 'storage' point in which different processes interact. This storage point can be either a physical storage point (inventory) or an information storage point (database). For instance, the order status database is used as an information decoupling point between the billing process and the order delivery process. The delivery status in the database is changed to 'delivered' by the delivery process. The billing process checks this status and determines to send a bill to the customer. A DP is a PDP which separates the forecast driven processes in an organization from the customer specific processes.

The term *supply chain management* (e.g. Houlihan 1985, Scott & Westbrook 1991, Towill *et al.* 1992) has been coined to denote the management of the goods flow across several organizations, ideally from the raw materials extractor to the final consumer. Coordination between members of the chain becomes increasingly important.

3.3.2 A classification of logistics organizations

With logistics organizations we mean organizations that have to control, either directly or indirectly, goods flows. We will present a classification of logistics organizations, followed by a partial classification of logistics dyads. The capacity and material problems are used to derive the classification. We feel that the resulting classifications convey the essentials of logistics organizations and logistics dyads.

The capacity problem refers to the responsibility of an OU to have the right amount of capacity available to transform a goods flow, e.g. production capacity, handling capacity, and storage capacity, in order to achieve a certain level of customer service. (Capacity of administrative personnel is not considered capacity in our classification). Similarly, the material problem refers to having the right amount of material available to meet customer demand to a predetermined extent. The classification of logistics organizations using the capacity and material problem as criteria, is given in Table 3.1. The term 'producing' in the acronyms denoting the different classes, is used in the broad sense to denote all logistics OUs that must assure the availability of physical products that are sold, possibly after transformation, to customers.

Table 3.1 - A classification of logistics OUs

	No material problem	Material problem
No capacity problem	Logistics service mediators • e.g. forwarders, brokers **MSLS**	Term goods merchants **MPLS**
Capacity problem	Logistics service providers • e.g. transporters, public warehousers **SLS**	• Manufacturers • Wholesalers, Retailers **PLS**

S=service M=mediating P=producing LS=logistic system.

The internal design of PLSs and SLSs
In logistics networks most organizations have both an IAS and a GAS. In terms of our classification these are Service Logistics Systems (SLSs) and Producing Logistics Systems (PLSs). In Figure 3.10 the internal design of a PLS and a SLS are shown schematically. For this simplified PLS the determinants of the internal design are:

- the location of the DP
- the level of inventory in the DP
- the level of capacity before and after the DP
- the net production time before and after the DP.

With net production time we mean the time it takes to transform and/or deliver the goods assuming infinite capacity. For the simplified SLS there is only one determinant of the internal design:
- the level of capacity.

Description PLS. There are two main processes in a PLS: an input process which is triggered by the supply order (S-ORDER) resulting from the planning task, and an output process triggered by customer orders (C-ORDERS). Depending on the type of PLS there can be a third process, the transformation process. This further refinement of PLSs is not needed for our purposes. If there is a transformation process this is assumed distributed over the input and output process, the exact distribution depending on the location of the DP. The planning task produces the sales forecast which governs the logistics process up till the decoupling point (DP). If a PLS fully sources and produces to customer order, there will not be a planning task, nor will there be a DP. If this is the case there will only be one process that is triggered by the customer order, and of which the supply order will be an integral part. In a PLS the capacity can be divided in input- (Cap_i), storage- (Cap_s), and output capacity (Cap_o).

Description SLS. A SLS sells capacity and must assure that it has enough capacity to fulfil a certain amount of customer orders, through process I. The planning task in the SLS is used to order extra capacity if needed, process II.

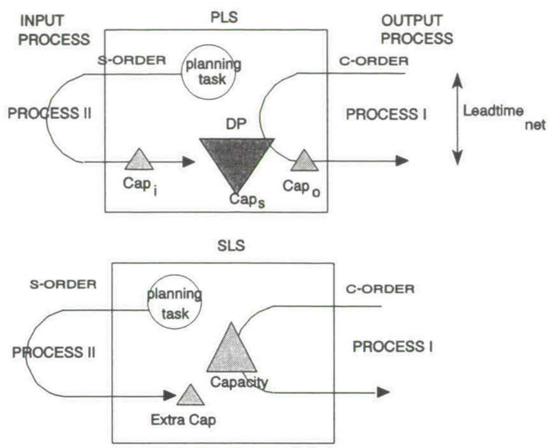


Figure 3.10 - A production logistics system (PLS) and a service logistics system (SLS)

Next a classification of logistics dyads consisting of PLSs and SLSs is given. The major criterion apart from the logistics types of the constituent OUs is the cascade order.

The cascade order. The cascade order refers to the direction of the goods flow relative to the direction of the internal order flow (see Figure 3.11). If the directions coincide we call the VAP a *forward cascade*, and if the direction of the goods flow opposes the direction of the order flow, we call the VAP a *backward cascade*. The OU which sends the internal order is called the *superior*, the one receiving the internal order the *subordinate*.

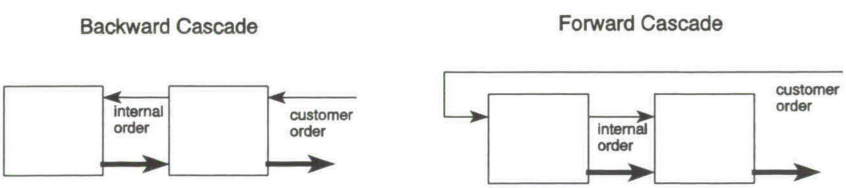


Figure 3.11 - Backward and Forward cascade order

The logistics dyad types

Our classification of logistics dyads is based on the logistics system type of superior and subordinate and the cascade order. All combinations of SLS and PLS types of logistics systems in a VAP are given in the following table, of which only six are possible, since a SLS cannot be the superior to a PLS in a dyad. A SLS which by definition receives customer orders for capacity will not need any output of a PLS related to that order.

Table 3.2 - A classification of dyadical relationships

Cascade Order	Superior-Subordinate	Examples
Backward	SLS - PLS	(Not possible)
	PLS - PLS	A producer and supplier, or a wholesaler and a producer
	SLS - SLS	A liner and a stevedore
	PLS - SLS	A producer with an external warehouser for parts
Forward	PLS - SLS	A producer with external warehouser for finished product
	PLS - PLS	A producer with a subcontractor at the market side
	SLS - SLS	A warehouser with an external transporter
	SLS - PLS	(Not possible)

PLS = Production Logistics System   SLS = Service Logistics System

3.3.3 Logistics performance measures

Logistics performance measures are needed for two reasons. First they are needed as criteria to *evaluate* alternative designs (see Figure 3.2) and secondly they are needed in the day to day operation of organizations for *control* purposes. Planning and control are a vital part of management in general (Euske 1984), and for logistics management in particular. Control refers to the set of activities by which one determines if plans, executed by some process, are adhered to. Thereto one has to measure the performance of the 'executing process'. Our interest is in the use of performance measures for the evaluation of alternative designs. Before stating our selection of performance measures, a brief introduction to logistics performance measurement is given.

An introduction to logistics performance measurement

At higher management levels financial measures (such as budgets and costs) are more common than physical ones for planning and control. While at the operational level of the organization measurements of physical quantities (such as delivery reliability and lead times) are applicable. This 'measurement gap' (see Andersson *et al.* 1989) becomes a problem at the middle management level where the upward communication is in terms of guilders, while the downward communication is in terms of physical quantities. Even at the strategic level, the use of physical performance measures is unavoidable, simply because they cannot be expressed in guilders, and are still of strategic importance to the organization. A typical example of differing units of measurement is the inventory level. It will be expressed in guilders when used by the accounting department, while the inventory level will be expressed in number of SKU's by the production planning department.

Cost is a financial performance measure of great operational relevance. Costs are either:
- inventory carrying costs (supply, work in process, finished goods),
- production cost (in the broad sense of the term, e.g. also transportation cost),
- and materials cost (raw and packaging materials).

How these cost are measured is currently a topic of much interest since traditional cost accounting methods are not capable of producing logistically relevant cost related performance measures. Cost can for instance be measured per product, or per customer, depending on the type of control decision to be supported. A further discussion of this topic is beyond our scope, and the interested reader is referred to the literature.[9] The following examples illustrate the interaction or trade offs between cost and physical performance measures. Figure 3.12 gives a typology of performance measures.

EXAMPLES

(a) Increased delivery reliability can be obtained by keeping higher safety stock, but this increases inventory cost.
(b) Shipping by air instead of by rail induces a higher transportation cost, but will reduce the lead time.
(c) Purchasing cheaper subassemblies with a higher failure rate reduces the materials cost, but reduces the quality of the final product. •

Cost:	inventory	(work in process, finished goods)
	material	(for a manufacturer)
	production	(labor, transportation, distribution etc.)
Customer service:	service level	(e.g. product availability, size assortment)
	product quality	(e.g. failure rate, condition)
	delivery reliability	
	flexibility	
Time:	lead time	
	throughput	(goods/time unit)

Figure 3.12 - A typology of performance measures

Hoebeke (1990) distinguishes three levels of performance measures/criteria. They are described below in descending order of hierarchy.

Effectiveness criteria. Evaluation of the purposefulness of the organization as a whole. Two basic questions are: Are the goals valid? Are we fulfilling the goals? An example of

[9] Kaplan 1988, Cooper & Kaplan 1991, Johnson & Kaplan 1987, Turney 1993, Swarte 1995.

the first question is: Given the competitiveness of the environment and the customer demands, is a norm for delivery reliability of 90% still valid? A question of the second type is: How able are we at fulfilling a delivery reliability of 90%? Measures pertaining to the first type of question are also referred to as measures of adequacy (Attkisson & Broskowski 1978).[10]

Efficacy criteria. Evaluation of the means used. The means represent the policies, programs, and procedures through which the goals and objectives are pursued (Ackoff 1970).[11] The basic question is: Are the right means used to achieve this effectiveness? These are criteria pertaining to the quality, that is the flexibility, sensitivity, robustness, and the reliability, of the logistics process. These criteria are actually evaluating the basic design choices of the logistics process. If for instance a certain level of flexibility is required in a production environment, this may imply the acquisition of a new machine (means).

Efficiency criteria. Evaluation of the parsimony of resource usage. The basic question is: Are the available resources and inputs used as optimally as possible? Most of the productivity and cost indicators are efficiency criteria.

The use of efficacy criteria is less common than the use of effectiveness and efficiency criteria. Some widely accepted definitions of the latter are given in Figure 3.13. The different levels of performance criteria are illustrated in the following simplified example.

EXAMPLE. A logistics service centre (LSC) picks, packs and expedites orders on behalf of its client who is a wholesaler. The wholesaler receives the orders from his customer, and then relays these orders to the LSC along with peculiarities for that customer. Orders can have the following delivery conditions:

- delivery date is fixed (e.g. october 31st, before noon),
- speed delivery (e.g. within 24 hours after order acceptance),
- no delivery date specified.

The LSC keeps the inventory and is also in charge of inventory control. A crew of ten persons picks and packs the orders in the morning and prepares them for shipment in the afternoon. The storage space is used as follows. At ground level the different articles are stored in pick-locations, each article having a fixed place in the warehouse. On the higher storage positions, the rest of the (bulk) inventory is positioned. If the ground inventory is depleted, an amount of articles that fits into the ground position is taken from the bulk inventory. This causes a delay in the picking activity. For orders for which no delivery date is specified the LSC strives for a delivery lead time of 3 days, a target which is achieved in 99% of all cases. This is a performance measure at the *effectiveness* level, and the 99% seems to indicate that the organization is quite effective. The norm of the performance measure of 3 days is, however, is not a valid one, since customers are used to receive their goods from competitors much sooner if they do not specify a delivery

[10] Secondary reference from Euske (1984), p.61.

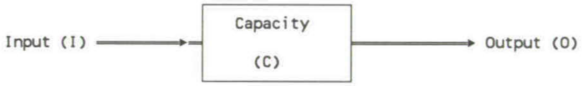
[11] Secondary reference from Euske (1984), p.20.

date. On busy days the LSC hires extra personnel from an employment agency. Since these unexperienced workers make a lot of mistakes in picking the goods, the quality of service is not up to standard on busy days. The means used by the logistics process is at stake here: should the organization have excess personnel to cope with peaks or settle for outside personnel and accept a lower quality of service? This discussion takes place at the *efficacy* level of organizational performance. Typical *efficiency* criteria used in the LSC are the utilization of storage space, personnel, and the average cost per delivery. ●

Measures, indicators, and norms. In practice it is necessary to distinguish performance indicators and norms from performance measures. The operationalization of a performance measure is called a *performance indicator*, e.g.

- the return on investment (ROI) ratio is an indicator for profitability;
- the standard deviation of lead time is an indicator for delivery reliability.

The desired value of a performance indicator is called a *norm*. Some widely accepted definitions of the most common performance measures, utilization, efficiency, productivity, and effectiveness are given in Figure 3.13. The performance indicator input (I) denotes the effort put into a system. I_{real} is the real effort put into a systems, and I_{norm} reflects a predetermined desired level for this indicator. A similar notation is used for the other indicators.



Utilization = C_{used}/C (resource efficiency)

Efficiency = $E_i = I_{norm} / I_{real}$ (input efficiency)

Productivity = P = Output/Input (process efficiency)

Effectiveness = $E_o = O_{real} / O_{norm}$

Figure 3.13 - Measures of efficiency and effectiveness
(Based on: In 't Veld 1988)

Many attributes or variables can be measured in an organization. Actually measuring all these variables will result in chaos and the manager will not be able to see the forest for the trees. Designing a performance measurement system (PMS) therefore not only includes determining the performance measures, but also includes determining which variables are to be measured and combined into a performance indicator. The following variables can be distinguished:

- input variables (e.g. production order)

- process variables	- design variables	(e.g. capacity)
	- state variables	(e.g. queue lengths)
- output variables		(e.g. number of late deliveries)

Performance measures for evaluating logistics design
The following performance measures are used to evaluate logistics designs, either of a single OU, or a dyad:
- cost,
- delivery reliability, and
- lead time.

Hence one of each category in our performance measure typology (Figure 3.12). Lead time and delivery reliability are measures of customer service. A designer tries to achieve desired levels for lead time and delivery reliability, while the cost is the 'prize he has to pay' for achieving shorter lead times and higher delivery reliability. Hoebeke (1990) calls this tension between contradictory measures of performance the 'organizational tonus', and links it to the viability of organizations. A single overall measure to evaluate a design is theoretically a weighted composite of cost, lead time, and delivery reliability.

Why these measures? What is their relationship to the design of coordination? In the next chapter we will explain in detail that coordination is caused by uncertainty. Uncertainty in a system may be reflected in the reliability of the output of that system. Lead time is related to uncertainty in the sense that in an uncertain environment, the longer the planning horizon, the more difficult it is to plan. Furthermore organizations can avoid having to deal with e.g. demand uncertainty by sourcing and producing to order as much as possible (moving the DP upstream). This will generally go at the expense of customer service in terms of the lead time. There clearly exists interaction between uncertainty on the one hand and reliability and lead time on the other. Hence both reliability and lead time are appropriate variables for the evaluation of a design when coordination (and its effect on uncertainty) is the major design variable.

3.4 Organizational change and (re)design

Organizations change continually, sometimes through evolution as though they were natural systems, mostly through deliberate intervention by man, i.e. through design. In this section literature on the understanding of organizational design (the noun) is reviewed. In subsection 3.4.1 the raison d'etre of relationships is discussed. In subsection 3.4.2 some determinants and descriptors of organizational form and relationships are discussed. In subsection 3.4.3 recent literature on (re)design is discussed. The discussion is not meant to be exhaustive, but rather to give an impression of the issues discussed in the literature in order to juxtapose them to the class (2) models required to fulfil the objectives of our study in section 3.6. Two established fields of interest, economics and organization theory, as well as the emerging field called coordination theory are reviewed (section 3.5).

3.4.1 The institutional economist's reasoning

The central question dealt with by the field of institutional economics is "Why are there firms?", i.e. why are economic exchanges organized within a firm and not within a market? If "in the beginning there were markets" (Williamson 1975, p.20), i.e. a barter society, why did firms emerge? And how do we explain the turning point from vertical integration to vertical disintegration and hybrids as we see today (see Figure 3.14)? It is not our intention to answer these questions, but merely to discuss a branch of science which tries to answer this type of question, transaction cost economics.

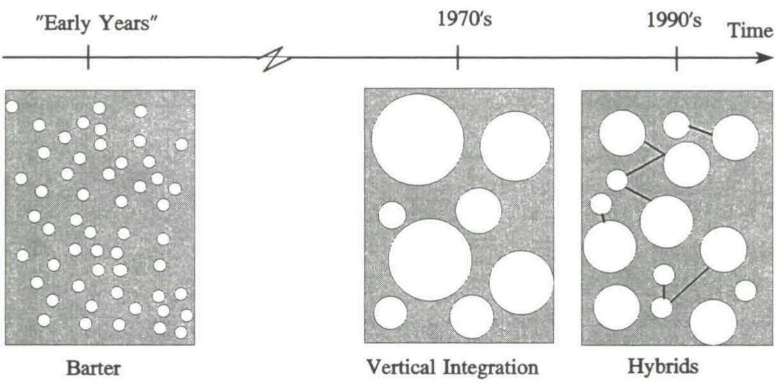


Figure 3.14 - Changing governance: from markets to hierarchies and hybrids

Within a market one can distinguish between one time transactions and transactions governed by long term contractual relationships. This raises the questions "Why are transactions governed by long term relationships and not within a pure market?" The 1991 Nobel Prize laureate Ronald Coase was the first to pose and answer this question in his seminal work the "Nature of the Firm" (1937). His work has been elaborated upon by Williamson (1975 and 1985), and is today known as transaction cost economics. The basic line of reasoning within this body of knowledge is summarized below.

(1) Markets and hierarchies (a term denoting firm) are alternative ways of organizing activities.
(2) Both ways of organizing incur costs. Costs incurred in the market mechanism are called transaction or external coordination costs and consist among others of the cost of designing and maintaining contracts. The costs incurred in a hierarchy are called internal coordination costs. In general, the larger the firm, the higher the internal coordination costs.
(3) Whether an activity should be internalized within a firm or bought in a market is

determined by the relative efficiency of each mode: a transaction is internalized when the internal coordination and production costs are less than the transaction and external production costs.

Transaction costs are determined by:
- the frequency with which the transaction occurs,
- the degree of uncertainty and complexity of the transaction,
- the asset specificity of the transaction which "... has reference to the degree to which an asset can be redeployed to alternative uses and by alternative users without sacrifice of productive value" (Williamson 1991, p.281).

The higher the frequency, degree of uncertainty and complexity, and asset specificity, the higher the transaction costs, and the more an organization will tend to incorporate an activity rather than buying it in the market. We like to emphasize that the cost indicators that are used to compare different modes of organizing should reflect the logistics measures of performance. The production costs, whether internal or external, are the costs made for producing according to given measures of logistics performance, e.g. lead time, delivery reliability.

A critique on transaction cost economics in the literature is that the taxonomy of governance structures encompasses only pure markets and hierarchies. Intermediate governance mechanisms involving long term relationships (hybrids, network firms) are not dealt with. In a more recent paper (1991), however, Williamson does distinguish this third type of organizing.

Effect of information technology on organizational boundary

Following the line of reasoning of transaction cost theory Malone *et al.* (1987) predict that information technology (IT) through its reduction of the external coordination costs will lead to an overall shift towards more market relationships (see Figure 3.15). Since they do not distinguish hybrids, we assume that these are considered market relationships. This statement is not entirely true. Yes, IT enables organizations to concentrate on their core business and to buy products and services, which is a shift towards the market end of the inter organizational continuum. At the same time, however, IT enables closer relationships between organizations which were before only loosely coupled, which is a shift in the opposite direction. Malone *et al.* also note that organizations purchase more externally, while at the same time reducing the number or suppliers. While they call this 'paradoxal'(p.494), we view it as a consequence of the fact that their prediction of a generic shift towards more markets is too simplistically stated.

We distinguish three types of shifts that may be attributed to IT, without commenting on which of these will be dominant:
- a shift from hierarchy to hybrids,
- a shift form market relations to hybrids, and
- a perfection of the workings of the market mechanism (electronic markets).

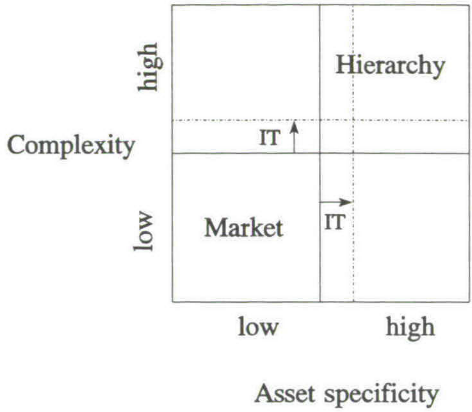


Figure 3.15 - How IT increases the asset specificity and the complexity that can be coped with by markets (source: Malone *et al.* 1987)

Notice that Coase in 1937 used the telephone, another boundary crossing technology, as an example of a technology which might effect organizational boundary:

> "It should be noted that most inventions [technology] will change both the costs of organising [hierarchy] and the costs of using the price mechanisms [market]. In such cases, whether the invention tends to make firms larger or smaller will depend on the relative effect on these two sets of costs. For instance, if the telephone reduces the costs of using the price mechanism more than it reduces the cost of organising, then it will have the effect of reducing the size of the firm." (the additions within brackets are ours)

Proposition A transaction is internalized when the internal coordination and production costs are less than the transaction and external production costs. The higher the asset specificity, uncertainty and complexity, and frequency of a transaction, the higher the transaction costs.

3.4.2 The organization theorist's description

We will next present some results of the inter organizational perspective of organizations which are useful for our study of a specific type of inter organizational construction, the dyadical VAP. Van de Ven *et al.* (1975) distinguish three broad categories of literature on inter organization theory each applying to a different level of analysis.(p.4, p.20 ff):

- the environmental level,
- the interaction level, and
- the social system level.

At the *environmental level* the objective is to understand the characteristics of the environment itself and to assess their impact on a given organization. The unit of analysis if thus a single organization to which an open-system perspective is applied. At the *interaction level* sets of organizations which interact frequently are identified and their interaction processes are studied. Concepts applied at this level of inter organization theory are 'task environment' and 'organization set'. The *social system level* studies organizations from the perspective that social units are parts of a total social system. The relationships among different organizations are studied from this perspective. The term inter organizational field is used in studies at this level. This latter level is clearly beyond the scope of our research. Elements of studies of the first two levels are given next, along with their interpretation for dyadical VAPs.

The concept of environment can be divided in a general environment and a specific environment (Hall 1972). The general environment includes those conditions that indirectly affect an organization, such as technological, political, economic, and cultural conditions. The specific environment refers to that part of the environment with which an organization directly interacts and is also called the task environment (Thompson 1967). Thorelli (1967, p.66) has defined it as "that part of the total setting with which the organization is transacting and in which it is competing". Task agents are: customers, suppliers, employees, competitors, distributors, governmental agencies, stockholders, and regulatory groups. For our study the following actors in the task environment are important:

- customers
- suppliers
- distributors, or more generally, logistics service providers.

Within contingency theory the environmental characteristic which most prominently affects organizational form is *uncertainty*. The greater the environmental uncertainty experienced by an organization:

(1) the more adaptive and organic the structure,
(2) the more differentiated the orientation of managers,
(3) the greater the lateral communications and participativeness in decision making by employees,
(4) the greater the internal problems of coordination and control.

The first and the last of these points abstract from individuals and are hence usable in our analysis in which organizational units and tasks are the units of analysis. The adaptive and organic structure that is required in environments of high uncertainty may explain why organizations outsource tasks (see e.g. Harrigan 1985) and form partnerships. The adaptiveness should also be applicable to the partnership itself.

The fourth point above suggests that high environmental uncertainty induces problems for internal coordination and control. We would like to contend that this depends on how well the organization succeeds in establishing an adaptive and organic structure. Indeed, a bureaucracy will have problems of internal coordination and control in an uncertain environment. The fourth point has relevance to VAPs, but we first need to make the distinction between uncertainty in the sense of unexpected phenomena, called *disturbances* (i.e. deviations from expectancies), and uncertainty in the sense of expected phenomena which have stochastic occurrence patterns, such as demand uncertainty.[12] The latter type of uncertainty can be resolved by choice of operational coordination mechanism in a VAP. The first type of uncertainty, when it has a long term effect, may require an adaptive and organic structure at the strategic or contract level of the VAP. This will require renegotiating the contract or even termination of the VAP. This view is supported by Williamson (1992, p.291): ".. the hybrid mode could well become nonviable when the frequency of disturbances reaches high levels".

Proposition In an environment of high (operational) uncertainty designing of coordination and control become critical activities

Proposition In an environment with a high disturbance level VAPs must strive for coordination at the strategic level, i.e. strive for an adaptive and organic structure, or end the partnership (non-viability).

Aldrich (1975) describes four dimensions by Marett (1971) of inter organizational relations (p. 57 ff).[13] Because the first three dimensions "... deal with the background conditions and general terms of a relation between organizations", while " ... the standardization dimension concerns the specific details of a transaction" (Aldrich 1975), we will only discuss the fourth, standardization, dimension. *Unit standardization* refers to the fixedness of the unit of exchange. In terms of logistics, this refers to the specifiability of the goods or services transacted, i.e. a finite number of attributes to describe a goods or service, and a finite number of values these attributes can have. *Procedural standardization* refers to the fixedness of the procedures of exchange. At one end of the spectrum all transactions are dealt with according to fixed procedures, at the other end of the spectrum all transactions are dealt with on an ad hoc basis.

In a VAP the unit of exchange need not be standardized, nor need the procedures be standardized. Thus even tough the relationship is formalized in a contract, the actual transactions need not be standardized. However if the VAP is going to use EDI as a means of communication, both these sub-dimensions need to be standardized. The unit of exchange need to specifiable in terms of a finite, predetermined number of attributes, and the procedures of exchange need to be determined upfront.

[12]It is known that customer orders will arrive at the organizational boundary, it is just not known when, and how large they will be.

[13]The following four dimensions are distinguished. (1) The nature of formalization: (a) agreement formalization, (b) structural formalization. (2) The intensity of involvement: (a) size of resource investment, (b) frequency of interaction. (3) The nature of reciprocity: (a) resource reciprocity, (b) definitional reciprocity. (4) The nature of standardization: (a) unit standardization, (b) procedural standardization.

Proposition A high level of environmental disturbances has a negative effect on procedural standardization.

Proposition Procedural standardization is a requirement for the use of EDI in a VAP.

3.4.3 Business Process Redesign

Recently several of articles (Kaplan & Murdock 1991, Davenport & Short 1990), and even books (Davenport 1993, Hammer 1993, Johansson *et al.*) have appeared on process redesign or reengineering. The notion of changing operational processes is not new, and has been the subject of a number of disciplines concerned with business improvement, e.g. integral logistics, system thinking, industrial engineering (see Davenport 1993, pp.311 ff for an overview of the precursors of process redesign). The renewed attention of this subject has its roots in consultancy rather than academics, which is seen as an indication of its practical relevance. The academic community, to a lesser but increasing extent, is picking up the subject (e.g. Venkatraman 1991, Dur 1992, Creemers 1993). Thus far, most of the literature consists of rules of thumb based on the experience of business consultants, and not on some basic of understanding of the underlying business processes. In this respect the literature on reengineering is not of much help to academics. What does emerge from the literature is that it is essential to adopt a process rather than a functional perspective in the (re)design of business processes.

It is this perspective which enables us to speak of boundary crossing logistical processes, and which has emphasized coordination as a way to make boundaries permeable, so that processes are not hampered by them. In chapter five we will elaborate upon the process perspective which we have embedded in a simulation tool, while the coordination needed to make processes truly boundary crossing is the subject of the next chapter. In this section we will give a review of some of the literature on the reengineering.

Hammer (1990) with his often cited statement "Don't Automate, Obliterate" emphasizes the need to distinguish between automation and rationalization on the one hand and redesign on the other. Merely automating old ways of working ("paving the cow paths") may speed up the processes, but leaves their fundamental deficiencies in place. Deficiencies result from the fact that most of the current processes in organizations were designed in a time when efficiency and control were the leading paradigms, while in today's competitive environment speed, service and quality are the watchwords. Hammer argues that reengineering cannot be planned in detail, requires drastic change, and its results are uncertain. He suggests that future redesigners can benefit from the rules of thumb derived from preceding successful cases, and then states the following principles of reengineering:

- Organize around outcomes, not tasks;
- Have those who use the output of the process perform the process;
- Subsume information-processing work into the real work that produces the information;
- Treat geographically dispersed resources as though they were centralized;

- Link parallel activities instead of integrating their results;
- Put the decision point where the work is performed, and build control into the process;
- Capture information once at the source.

Davenport & Short (1990) in their article on what they call the new industrial engineering focus specifically on IT induced redesign of business processes. The basic notion underlying the approach they advocate is that of "... customer driven processes that cross organizational boundaries..". Opposed to Hammer who perceives business redesign as a very unstructured, uncertain process, Davenport & Short perceive it as a straightforward process consisting of five steps:

(1) Develop business vision and process objectives;
(2) Identify processes to be redesigned;
(3) Understand and measure existing processes;
(4) Identify IT levers;
(5) Design and build a prototype of the process.

According to Kaplan & Murdock (1991) an organization has only a few core processes, usually three or four. For instance a manufacturer's typical core processes are new product development, order generation and fulfilment, and integrated logistics. They emphasize process thinking as opposed to functional thinking and mention several benefits of this approach, e.g. the results- or customer oriented perspective and the use of cross functional performance measures. A five phase approach to redesign is proposed.

Phase 1: Identifying processes;
Phase 2: Defining performance requirements;
Phase 3: Pinpointing problems;
Phase 4: Developing a vision;
Phase 5: Making it happen.

In their experience there are several factors critical to the success of redesign project, which include leadership, a single point of accountability, and creativity.

Rose & Sharman (1989) focus specifically on the redesign of logistics. IT offers opportunities to really design and implement processes according to the integrated logistics concept. They identify five IT based principles to radically redesign logistics configurations:

- Moving the order penetration (or decoupling) point;
- Differentiating the logistics approach;
- Integrating decision support systems and databases;
- Managing beyond boundaries;
- Redesigning products for logistics friendliness (improving the product structure).

They propose a three stage approach in the 'journey' towards integrated logistics:

Stage 1: Developing an operational blueprint;
Stage 2: Assessing organizational readiness;
Stage 3: Implementation.

Evaluation
This practically oriented literature presents class (1) models, i.e. prescriptive conceptual approaches to (re)design (see Figure 3.4). Cases and examples are used to illustrate the model's application in practice. We endorse the recommendation by Davenport & Short (1990) for prototyping (their fifth step), and have for this purpose developed a simulation tool. This is an approach of class (4) to (re)design.

The authors (all but Hammer) each offer a method to approach business process redesign. A usual step for us would be to try to integrate these and come up with a method containing the best of the other methods. Although this would be of practical relevance, we feel that the real challenges in redesign are not in how to do it, but more in what to do! We already emphasized this and defined in section 3.1 the development of type (2) models opposed to type (1) models as our objective: models or theory on the object of (re)design. We feel that in the end "process innovation remains more art than science" (Davenport 1993, p.18).

3.5 Prior theory on coordination

In section 3.2 we briefly touched upon the concept of coordination and distinguished between operational and design coordination. In this section existing theory on coordination is reviewed. This literature focuses on intra organizational and inter personal coordination. In the next chapter we will extrapolate parts of this theory to coordination between organizations. The work two well known authors on coordination, Mintzberg and Galbraith, is discussed, and an emerging field called coordination theory is described.

3.5.1 Intra organizational coordination: Mintzberg and Galbraith

In his work on the structuring of organizations, Mintzberg (1979, 1988) argues that characteristics of organizations fall into natural clusters or configurations. The elements which make up these configurations or organizational types are:
- the basic parts of organizations,
- the coordination mechanisms,
- the parameters used to design structure, and
- the situational factors.

Of interest here are the coordination mechanisms. The need for coordination arises as a logical consequence of the division of labor in organizations. The coordination mechanisms "as the basic means to knit together the divided labor of the organization, serve as the most basic elements of structure - the glue that holds the organization together" (Mintzberg 1988, p. 280). Six mechanisms are distinguished for the coordination of work:
(1) Mutual adjustment,

(2) Direct supervision,
(3) Standardization of work processes,
(4) Standardization of outputs,
(5) Standardization of skills,
(6) Standardization of norms.

The latter two are very specific for coordination between people in an organization. The first four mechanisms can be applied to coordination between organizations. In the case of mutual adjustment, no arrangements are made prior to a transaction, and the terms of a transaction are jointly determined for each occurring transaction. In the case of direct supervision the task of coordinating the goods flow between two organizations is in the hands of a third party. E.g. a forwarder who coordinates the goods flow between a shipper and a transporter. In the case of standardization of work processes organizations have agreed on the procedures to govern their transactions prior to the actual transactions' occurrence. This is the mechanism mostly used in VAPs. In case of standardization of outputs, the transactions for a certain period of time are predetermined and fixed, and are laid down in a plan.

Galbraith (1973, 1977) is probably the best known author on the coordination of intra organizational activities. He adopts an information processing perspective of organizations, an approach we will prolong in our theory of logistical coordination. The aim of Galbraith's work is to produce an organizational design framework. He defines the organizational design problem as achieving coherence or a fit among strategy, organizing mode, and integration of individuals. The organizing mode entails:
(a) the decomposition of the overall task into subtasks, and
(b) the design of ways to reintegrate the subtask into the completion of the whole task of the organization.

The majority of his work is devoted to the reintegration of subtasks, i.e. the mechanisms for achieving coordination.

Table 3.3 - Comparison of Mintzberg's and Galbraith's coordination mechanisms

Galbraith	Mintzberg
Hierarchy	Direct supervision
Rules and Procedures	Standardization of work processes
Goal setting	Standardization of output
Environmental management	--
Creation of slack resources	--
Creation of self-contained tasks	--
Investment in vertical information systems	Direct supervision
Creation of lateral relations	Mutual adjustment

'Uncertainty' is the central notion of Galbraith's organizational design framework, which is tricky since as he puts it "there is a lot of uncertainty about uncertainty" (Galbraith 1977, p.26). The basic effect of uncertainty is that it disables organizations to preplan activities, i.e. to plan activities in advance of their execution. Galbraith distinguishes eight ways of coping with uncertainty, the first three of which are concerned with information processing. Organizations process information basically in three ways:

(1) information processing through the hierarchy of authority,
(2) information processing through rules and procedures (process related), and
(3) information processing through planning and goal setting (output related).

If the uncertainty of a task increases, so will the number of exceptional situations that are not covered by (2) and (3). Hierarchical referral will be used for these exceptions, and high levels of uncertainty will cause an overload of the hierarchy. In order to improve the coordination of activities (when goal setting, hierarchical referral, and rules and procedures do not suffice), the organization can adopt one of five strategies (Galbraith, 1977). The first three of which alleviate the need for information processing, while the last two increase the information processing capacity:

(4) environmental management,
(5) creation of slack resources,
(6) creation of self-contained tasks,
(7) investment in vertical information systems, or
(8) creation of lateral relations.

The first three alternatives are strategies ((4), (5), and (6)) that actually alleviate the need for coordination. The creation of slack resource has an interaction cushioning effect, while the creation of self contained tasks has an interaction minimizing effect (decoupling). Through environmental management the organization tries to reduce the uncertainty imposed on the organization by the environment. Strategy (7) is merely a reinforcement of the hierarchical referral mechanism. The eighth strategy resembles Mintzberg's mutual adjustment. In fact, all of Galbraith's strategies, apart from those that alleviate the need for coordination, can be mapped onto Mintzberg's mechanisms (see Table 3.3).

3.5.2 The emergence of coordination theory

Coordination is an old topic, receiving renewed interest today, because it is an effort which may be supported by information technology. Holt (1985) introduces the term *coordination technology* to refer to software technology for the coordination of work in electronic work environments. In a later publication (Holt 1988) a graphical language for the study and implementation of coordination is introduced. The main contribution of this language is that it makes the coordination effort explicit. The language is used for the specification and, through appropriate interpretation, for the implementation of software that coordinates the tasks of people in a distributed electronic work environment.

The interdisciplinary study of coordination as proposed by Malone (1988) draws upon a variety of different disciplines including computer science, organization theory, management science, economics, linguistics, and psychology. Three reasons why this work is timely also delineate the areas of application. First the wide spread use of computers by people for their work and the resulting access to computers opens the possibility of using computing and communication capabilities for the coordination of the individual's work. The second reason is that IT changes the ways communication and coordination are conducted, in combination with the increasing importance of global inter organizational interdependencies and the need for more flexible and adaptive organizations. The third reason given is the exploration of distributed and parallel processing computer architectures, which require coordination. The areas of application of coordination theory hence seem to be:

- coordination of intra organizational activities, i.e. between people,
- coordination of inter organizational activities, and
- coordination of computer processes.

Table 3.4 - Components of coordination (Malone 1991)

Components of coordination	Associated coordination processes
Goals	Identifying goals (e.g., goal selection)
Activities	Mapping goals to activities (e.g., goal decomposition)
Actors	Mapping activities to actors (e.g., task assignment)
Interdependencies	"Managing" interdependencies (e.g., resource allocation, sequencing, and synchronizing)

Malone defines coordination as the act of working together, and coordination theory is defined as the body of principles of how activities can be coordinated. Problems (see Table 3.4) for coordination theory are (Malone 1991, p.4):

> "How can overall goals be subdivided into action? How can actions be assigned to groups or individual actors? How can resources be allocated among different activities? How can information be shared among different actors to help achieve the overall goals?"

From the definition of coordination and the above mentioned problems of coordination theory, it is obvious that Malone's concept of coordination is an inclusive one, including the division of labor. We find this too broad a conception of coordination, and consider only one of Malone's activities, managing interdependencies, to be coordination (as does Galbraith).

3.6 Evaluation

3.6.1 Juxtaposition of extant literature to our requirements

In the first chapter we have stated as one of our problems: obtaining understanding on logistical coordination between organizations. The literature in organization theory regarding inter organizational relationships has the following characteristics from this study's point of view.

- Within the contingency perspective, which is the first movement within organizational theory that does not focus on a single isolated firm, only the impact of the environment on a single organization, and not on an IR is assessed (see Figure 3.16).
- Uncertainty is identified as a major variable for determining organizational structure and process. Most of this literature does not distinguish between environmental change, and predictability of change, thereby wrongly equating change and uncertainty (Miles and Snow 1978, p.253)'
- The concept uncertainty is not elaborated upon (as was already suggested by the preceding remark). No distinction is made between uncertainty and disturbances.

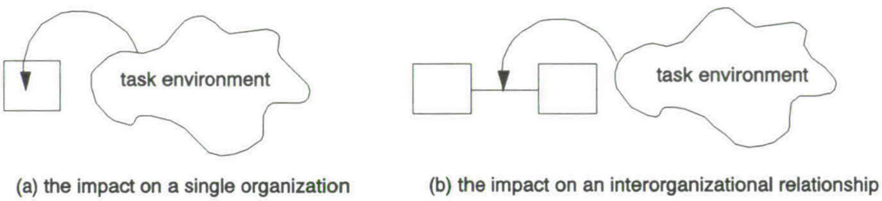


Figure 3.16 - The scope of organizational theory (a) versus the scope relevant to this study (b).

Furthermore organization theory treats the concept of coordination either from an intra-organizational or an interpersonal perspective. The literature which does deal with inter organizational relationships has a strong sociological focus (e.g. Marett 1966). Miles & Snow (1978, p.249) point out that most of the literature in organization theory focuses on the description of characteristics of existing relationships, and does is not concerned with the second order dynamics of the relationship, i.e. with the explanation of how relationships come into existence.

This issue is specifically addressed by institutional economics, in particular transaction cost economics. The literature explains the internalization of transactions in terms of the costs of internalizing that transaction versus the cost of acquiring products in the market. Critique that the dichotomous representation is too simple is being tackled, evidenced by the abundant literature on hybrids, network organizations, etc. The transaction cost theory does not address how, once an economically viable relationship has been established, this relationship is coordinated operationally, i.e. this theory does not deal with the first order dynamics of relationships.

Coordination theory as described by Malone and Holt does concern itself with operational coordination. However, this is an emerging field, which seems to be taking off in the direction of the (support of) coordination between individuals (often intra organizational but not necessarily so, e.g. coordination between engineers in joint manufacturer-supplier R&D projects).

The relevant lessons drawn from the existing literature have been summarized in the form of propositions in section 3.4. (It is not our intention to test these propositions.) In Table 3.5 they are restated along with an indication of whether they pertain to the strategic or operational aspect of organization.

Table 3.5 - Relevant propositions from existing literature

Aspect of organization	Proposition
Strategic	• A transaction is internalized when the internal coordination and production costs are less than the transaction and external production costs. The higher the asset specificity, uncertainty and complexity, and frequency of a transaction, the higher the transaction costs. • In an environment with a high disturbance level VAPs must strive for coordination at the strategic level, i.e. strive for an adaptive and organic structure, or end the partnership (non-viability).
Operational	• In an environment of high (operational) uncertainty designing of coordination and control become critical activities • A high level of environmental disturbances has a negative effect on procedural standardization. • Procedural standardization is a requirement for the use of EDI in a VAP.

The first set of propositions, the strategic level propositions, are beyond the scope of this study. They say something about the context within which VAPs come into existence. The second set of propositions concerns operations of a VAP. It contains elements (uncertainty, disturbances, procedures, coordination, control) upon which a theory of (operational) logistics coordination should elaborate.

3.6.2 Towards a theory of logistics coordination

What is lacking in the literature is a theory on the coordination of operational business processes across different organizations. We propose two reasons why such a theory is timely and has not received much attention before. Firstly, the stronger emphasis on logistical performance across several firms in the chain requires improved coordination, instead of decoupling points in the form of inventory and delays. Secondly, the emergence of inter organizational coordination can be attributed to the improved capabilities of data-communication between physically distributed firms and the improved information processing capabilities within firms.

A theory on operational coordination is needed to design the communication part of Value Adding Partnerships. This understanding is hence a class (2) model (see section 3.1) and should have the following properties.

- It should explain and define the phenomenon called coordination (including the objective of coordination) between organizations.

- It should describe the mechanisms through which operational coordination is accomplished.

- It should identify the factors that affect coordination.

In the next chapter we will develop a theory which satisfies these requirements. Galbraith's notion of task uncertainty will be an essential part of our theory.

Chapter Four

A theory of logistics coordination

> *"Theories are nets cast to catch what we call 'the world': to rationalize, to explain, and to master it. We endeavour to make the mesh even finer and finer."*
> - **Popper**, The Logic of Scientific Discovery, 1961.

In this chapter elements of a theory of logistics coordination are presented. This theory should through enhancement of our understanding of coordination enable us to improve the operational design of VAPs. Some predictions with respect to the use of EDI as an enabler of redesign opportunities are made. The need for coordination arises because OUs have uncertainty about actions to be taken by other OUs. EDI enhances coordination by enforcing its uncertainty reduction effect. Redesign opportunities for EDI must hence be searched for in directions that call for more coordination, coordination which can subsequently be coped with by using EDI to support/enable the communication aspect of coordination, and the VAP design phase to design the decision making aspect of coordination.

4.1 Introduction

Our theory of logistics coordination describes the interaction between logistical systems, and the role of communication therein. It is not a theory about manufacturing, purchasing, transportation, or warehousing, but a theory about linkages between systems which may possess one or more of these functionalities. The theory is of a qualitative, rather than a quantitative nature.

Referring to the theoretical problem statement (section 1.4), the elements of the theory are presented in three consecutive steps. First (section 4.2 & section 4.3) a description and analysis is given of *what* logistics coordination is, *why* it emerges, and *how it can be accomplished*. In a second step (section 4.4) the *factors that influence* coordination are assessed, and the way of accomplishing coordination, the *coordination mechanisms*, are elaborated upon. These two steps constitute the descriptive and explanatory part of our theory. Finally, based on this description and explanation, some predictions concerning the potential *impact of EDI* on logistics coordination, including its potential for the (re)design of logistics coordination, are made (section 4.5).

4.2 Logistics coordination: its definition and rationale

The premise which lead to the development of a theory of logistics coordination is that organizations communicate to coordinate. *What* then is logistics coordination? *Why* do we need it in the first place? In order to sharpen our definition of coordination, we return to the 'what' question by comparing it with related concepts and confronting it with the definitions or perceptions of other authors.

4.2.1 Logistics coordination defined

We all have some intuitive understanding of what coordination is, and often we take it for granted, i.e. we are unaware of it. Coordination is most prominent when it is missing: it is easier to let a traffic light coordinate our actions on a busy street corner than having to do this ourselves. If there are no traffic lights we apply procedures, e.g. 'traffic coming from the left must yield', which result in coordinated behavior, preventing chaos from happening. Another example of coordination is making an appointment with the dentist. By doing so we avoid long waiting times or vain trips because the dentist is on leave. These are examples of coordination between people, but one can also think of coordination between computer processors (Dijkstra 1968), between organizations, or between producers and consumers on a macro economic scale. Although coordination has been called an elusive concept (Holt 1988) we will next work toward a definition of coordination between logistical systems and outline the distinction between communication, coordination, and cooperation.

Malone (1988) defines coordination as "the additional information processing performed when multiple, connected actors pursue goals that a single actor pursuing the same goals would not perform". In a later publication (Malone *et al.* 1991) coordination is broadly defined as "the act of working together", and narrowly as "the act of managing interdependencies between activities". The first definition (1988) is interesting since it implies that coordination arises when *boundaries* exist between actors. The latter definition implies the existence of *interdependencies* as the cause for coordination.

Ribbers (1980, pp.180-1) describes coordination as the goal oriented adjustment of decisions pertaining to the values of different aspects, regardless of the number of actors involved in the decision making. If there are multiple actors they must agree upon a goal which is shared throughout the coordination. In case the decisions are made by different actors, communication is needed to achieve coordination. We do not consider the special case of a single actor to be coordination, and call it control instead.

Taking Ribbers' definition as the point of departure we add, after Malone, that the decisions are made by different operational units and instead of the term 'aspects' the term variable is used. In case of logistics the relevant variables to be coordinated pertain to time (T)[1], place (X), and the physical object specification (PO). We will hence define logistics coordination as a combination of Malone's and Ribbers' definition. This definition of logistics coordination applies to coordination in both the design phase of a the VAP and the operational phase (see section 3.2).[2]

Definition

> *Logistics coordination is the timely and deliberate adjustment of decisions in different operational units (OUs) with respect to certain variables pertaining to either of the characteristics time (T), place (X) and physical object specification (PO) of the process of delivering a product or service.*

Variables concerning PO refer either to the attributes of a physical object such as its type, colour, quantity, or to the attributes of a resource, e.g. type, capacity. Within a given coordination effort several variables pertaining to either characteristic (time, place, physical object specification) may be adjusted. For instance, the variables in a certain coordination effort can be the following set (T_1, T_2, X_1, PO_1, PO_2, PO_3), where e.g. T_1 denotes the first variable pertaining to the characteristic time.

Examples of variables are the required:
- time of pick up, earliest time of delivery, latest time of delivery;
- place of pick up, place of delivery;
- number of containers, size of concrete boards, cubic meters of storage space.

Examples of values that variables can take on are:
- week # 42; february 2, at 16:00 hrs; february 3, at 08:00 hrs;
- Victoriastraat 583, Amsterdam; Port of Rotterdam;
- four of 20 ft., 4 x 4 ft., 20.

Decisions of different OUs are *adjusted* if the outcomes of these decisions are correlated. *Timely* indicates that the moment at which the adjustment occurs relative to the moment at which the product or service is delivered is relevant. *Deliberate* is added to exclude adjustment of decisions that are not within the span of control of both operational units observed, or adjustments of which not all OUs involved have awareness. E.g. consider

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[1] Coordination that merely concerns the variable time is called *synchronization*.

[2] This definition concerns the process of coordination. There is much to say, and indeed much has been said, about coordination in terms of organizational structures that guarentee or stimulate coordination, or human skills (see Mintzberg 1998 in chapter three). Our focus on only the process of coordination is in line with the demarcation given in chapter one. We interested in the design of processes and not, e.g. structures or human resource programmes. (This is not to say that these are not important or difficult.)

two different organizations, unaware of each other, using a single resource which is rented from a third party. The decisions by these two organizations to start a task using that resource will be correlated to some extent, without any deliberate adjustment, i.e. coordination, between the two organizations.

The consistency postulate. Notice from our definition that the phrase 'goal oriented' as used by Ribbers (1980) and the word 'goals' as used by Malone (1988) have been omitted. It is not a necessary requirement of coordination that the OUs involved share a goal. With a 'shared goal' we mean a single objective or performance measure that OUs strive for *together*. The only requirement for coordination is that the separate goals of the OUs are not in conflict. This is referred to as the *consistency postulate* by Mesarovic et al. (1970). Of course when actors coordinate, they have some purpose in mind that is being served, e.g. avoid collision in traffic, avoid idle time when visiting the dentist. This *purpose* or *effect* of coordination, should not be confused with a shared goal, as it may different for each of the actors involved (we will return to this topic in section 4.2.3). One of the advantages of a VAP is that the conflicts between separate goals are resolved in the design phase of the VAP. In addition shared goals, i.e. shared measures of (joint) performance among coordinating OUs, are often defined for a VAP.

4.2.2 The rationale of logistics coordination

In this section we will elaborate upon the reason of coordination, specifically for logistics systems. In the first part of our presentation the level of abstraction is raised to that of systems theory, in order to relate to the extant literature.

The need for coordination *may* arise when systems interact (recall the term *interdependencies* used in Malone's (1991) definition), implying that not all interacting systems are coordinated. An interaction is called tight when an event in one system immediately leads to an event in the other system, and is called loose when there is no direct relationship between system events. Two systems interact (see Figure 4.1) either because they (see also Emery 1987) are coupled (uni- or bidirectional), share a resource, or share a target system (or a goal). Systems are coupled when the output of one system becomes the input of the other (unidirectional), and vice versa (bidirectional). A target system is a system which has the outputs of both focal systems as its input. Thompson (1967) refers to bidirectional coupling as reciprocal interdependence, to unidirectional coupling as sequential interdependence, and to the sharing of a common target as pooled interdependence. He observes that the interdependencies, in the order in which they are mentioned, are decreasingly difficult to coordinate.

Systems interaction in case of a shared resource is tight when the resource is scarce, and loose when the resource is abundant. A systems coupling is loose when there is slack (of capacity and/or goods) and tight when there is no slack. Whether there exists interaction (and its tightness) for target sharing depends on the requirements of the target system and its ability to impose these on the two focal systems. In VAPs of more than two OUs, resource sharing and target sharing are types of interaction which deserve closer examination.

Be aware that we describe three types of interactions, which are not mutually exclusive and may hence occur simultaneously in a practical setting. Furthermore, we only describe basic types of interaction, and not how these interactions are dealt with, i.e. managed. It is very well possible that a third (or fourth in case of target sharing) OU manages the bilateral interactions described.

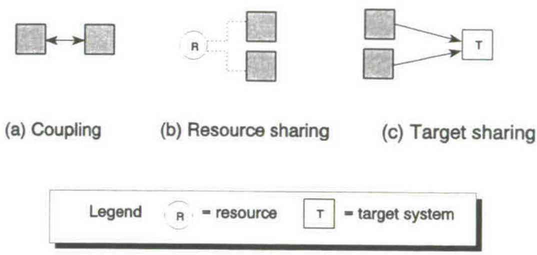

Figure 4.1 - Three types of bilateral systems interaction (after Emery 1987)

From here on we will focus on two systems that are *coupled*. The coupling between the two OUs manifests itself as an INTERNAL-ORDER($T_{1..k}$, $X_{1..l}$, $PO_{1..m}$) and subsequent flow(s) of goods from one OU to the other. One of the OUs in the dyad also gets an order from the customer of the dyad, ORDER($T_{1..p}$, $X_{1..q}$, $PO_{1..r}$). For either of the two OUs in the dyad to execute their order correctly, they need to have either the capacity, the material, or both available to meet the order specified. Consider for instance the two OUs depicted in Figure 4.2. Source OU denotes the source of the goods flow, while destination OU denotes the destination of the goods flow internal to the dyad.

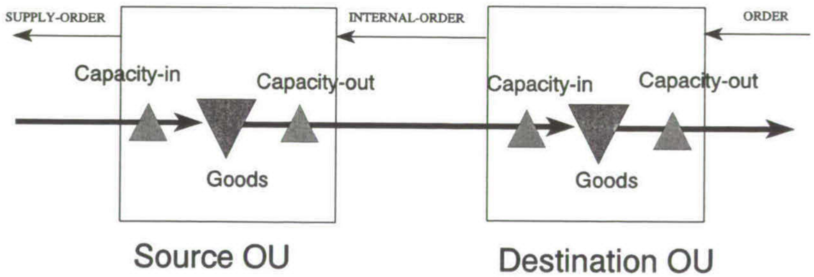

Figure 4.2 - An instance of coupled OUs

The destination OU in the dyad receives an ORDER to deliver certain goods. He must hence assure that he has the goods available to meet his customer's demand (*material* *problem*), as well as a capacity needed to deliver the goods to the customer (*outgoing capacity problem*). The material availability problems is concerned with sending the right INTERNAL-ORDER to the source OU at the right time, who then delivers the goods to the destination OU. The destination OU needs to have capacity available at a certain time and place for the handling of these incoming goods (*incoming capacity problem*). Such capacity can for instance be labour, transport capacity, or storage capacity. The source OU faces a similar capacity problem: it must have the capacity to assure that the right goods are delivered at the right time and at the right place (outgoing capacity). Apart from the capacity to deliver, the source OU must also assure that the goods are available for delivery (material problem).

The material availability problem need not always apply to the source OU. Consider for instance a warehouser who keeps inventory of parts on behalf of an assembly factory, and who delivers to that factory on order. The availability of parts in this example is not the responsibility (problem) of the warehouser, which hence only faces a capacity problem. Notice that the destination OU's goods availability problem is not elicited by the coupling between source OU and destination OU, but by the next downstream link in the chain, i.e. the customer of the dyad.

The three problems just described, the incoming and outgoing capacity problems, and the material availability (inventory) problem are referred to as the *control problems* of the OUs. Solving these problems without regard for the interaction with other OUs, will result in slack, both for capacity and for goods (buffer inventories). Taking regard of the interaction with others, requires coordination. Coordination aims at having the outcomes of the control problems be such that OUs interact in a favourable manner, i.e. in such a way that the performance in terms of cost, lead time, and delivery reliability[3] reaches a desirable level, for each of the OUs involved. Thus coordination is not a part of the control problem, but an activity which connects control problems of different OUs.

What, apart from the fact that OUs are coupled and wish to improve performance, makes coordination a useful effort? In other words, what other factors or conditions cause the need for coordination? Recalling that coordination is concerned with managing the interaction between OUs, the answer to this question is: uncertainty about actions in one OU which affect the other OU. If we focus on a VAP this uncertainty can be caused by the fact that at the time of designing the VAP, OUs face (operational) uncertainty in processes which is beyond their control, e.g. uncertainty in customer demand. Even if this were not the case, i.e. OUs operate in an unrealistic deterministic world, they have while designing the VAP uncertainty about how the other will act during operations. They must agree on some behavior that will result in adjusted (or concerted, or harmonious) decision outcomes. All this uncertainty may be resolved in the design phase of the VAP. The above line of reasoning is summarized in Figure 4.3, and in the following pragmatic

[3] See chapter three for an elaborate discussion of these performance measures.

definition of coordination.[4]

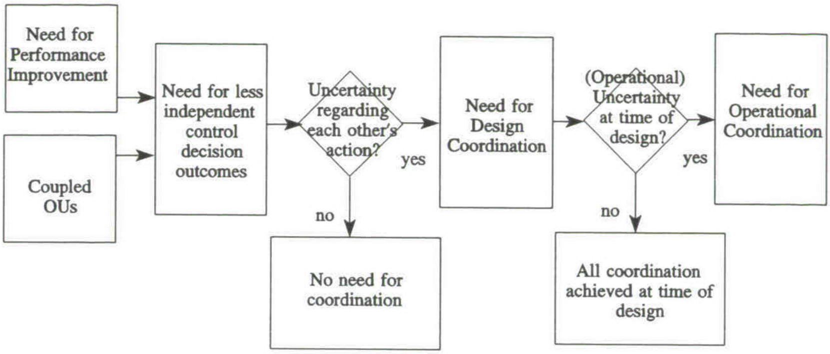

Figure 4.3 - The rationale of logistics coordination in a VAP

Definition

> *Coordination with other OUs is required if OUs when solving their control problems have uncertainty pertaining to the actions of other OUs. In a deterministic environment this uncertainty can be resolved in the design phase, otherwise additional operational coordination is required.*

4.2.3 Juxtapositioning to other definitions

There are many differing views on the notion of coordination, and related concepts such as communication and cooperation. The definition adopted in this study was given in the previous paragraphs. Here we will confront this definition to that of other authors. But first definitions of similar and much confused with concepts are given.

A model of internal organizational behavior
A simple model of internal organizational behavior is proposed here. This model is introduced in order to define a set of inter organizational processes and states. Among the interorganizational processes is coordination, the subject matter of this study. Coordination is an interorganizational process that can occur only in some interorganizational states, i.e. the state of consistency and the cooperative state.

[4] Leppänen et al. (1978; 2nd. ref. from Suomi 1990) refer to the Pragmatic, Semantic, Constructive definitions of something, which define 'the how and why of something coming into existence', 'the effect or purpose of something', and 'the workings and construction of something' respectively.

Organizational behavior at any point in time is described as follows (see Figure 4.4).

(1) A decision.
(2) A set of available courses of action, M.
(3) An organizational goal.
(4) Available information, V.

The organization at any point in time faces the decision of selecting a particular course of action, $m_j \in M$, that is most likely to lead to the fulfilment of the organizational goal. The decision is based on the information available. Information is that data in an organization that the organization considers relevant and on which it bases its decisions.[5]

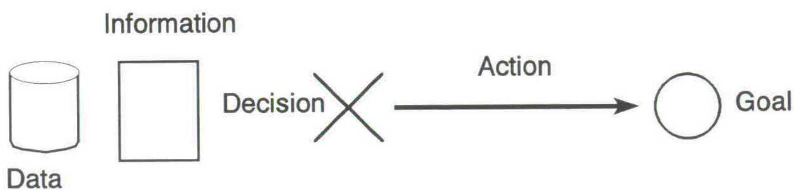

Figure 4.4 - A model of organizational behavior

Defining interorganizational processes and states
Based on the model just given the relationships between organizations in terms of the states and processes between organizations, can be described.

States
Depending on the goals of organizations an interorganizational relationship is either one of the following states.

A state of *conflict*: one organization pursuing its goal will prevent the other from attaining its goal to the fullest, and vice versa.

A state of *consistency*: both organizations can pursue their goals without affecting each other's goal attainment.

A state of *cooperation*: organization have defined a joint goal that they pursue together.

Processes
In the previous section we described interaction between organizational units. These interactions (coupling, resource sharing, target sharing) are 'hard wired' into the GAS. The processes described next refer to the relationships between organizational units in the IAS and between strategic decision making units (SDMUs) of organizations. They are described below in order of increasing pervasiveness (see Figure 4.5).

[5] The difference between data and information has been extensively elaborated upon elsewhere (see e.g Vervest 1986, p.35).

Data exchange results in an increase in data of the recipient, but does not affect the information of the recipient, and hence not the behavior of the recipient.

Communication is changing the available information of the communicators, and thereby influencing the behavior. Thus communication has an intended effect, whereas data exchange does not. This intended effect is referred to the pragmatics of a message communicated (see also chapter six).

Coordination is the adjustment of decisions leading to actions. Referring to our behavior model (Figure 4.4) this can be accomplished either by influencing each other's information or by direct influence on each other's decision. We will return to this discussion of coordination mechanisms in section 4.5. At least two organizations are actively and deliberately involved in a coordination process. Unilateral adjustment of decisions is therefore not considered <u>co</u>ordination.

Negotiation is the process between organizations trying to resolve their conflicting (sub)goals.[6] When an intermediary or third party is used in this process the negotiation is called *arbitrage*.

Cooperation is the process in which organizations work toward the same goal or subgoal. In defining this shared goal organizations are likely to have gone through a process of negotiation. Cooperation is likely to precede coordination. During the cooperation the organizations work toward the joint subgoal of determining the coordination mechanism. Again negotiation may be part of this process. Once the mechanism is determined, the cooperation process stops.

Confronting our definition with other authors'

Our definition of coordination is very explicit and may be viewed by others as a narrow perspective on coordination. The reason is that we are interested in operational processes in which formal communication (EDI) plays a dominant role. Although the definition is specific, we feel that it remains valid if one broadens one's design problem to include organizational structure and people (see also footnote 2). We will juxtapose our view on coordination to some of other authors in order to outline the difference and further clarify our position. Views differing from our definition of coordination are the following:

(1) Uncertainty is not the cause of coordination, conflict is.
(2) Organizations have a shared goal when coordinating.
(3) Even under conditions of complete certainty organizations may wish to coordinate.

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[6]Goals may be unravelled in a hierarchy of subordinate goals. Cooperation can take place at any level in the goal-hierarchy.

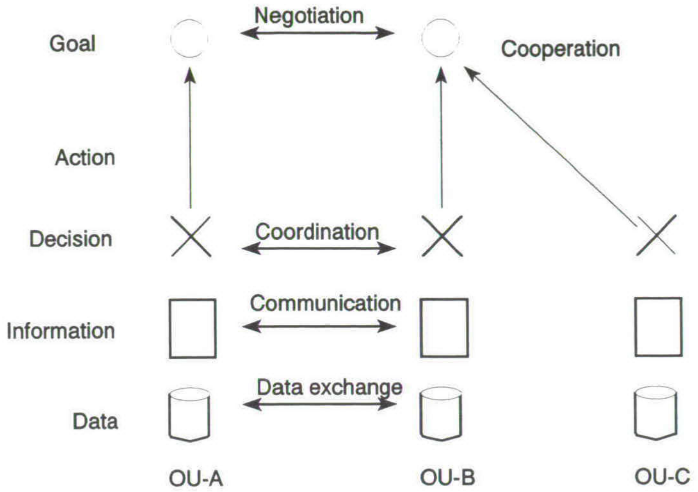

Figure 4.5 - Schematical depiction of interorganizational processes

Ackoff & Emery

Ackoff & Emery (1972) have a model of behavior that is richer than the model presented here. Our simple model is though sufficient for our purposes. They use their model to define concepts such as communication, conflict and cooperation. The notion coordination is not defined by Ackoff & Emery. According to Ackoff & Emery two actors are cooperating if the degree of goal attainment when they are part of the same environment is higher than the degree of goal attainment when one of them is removed from the environment. The opposite is true for actors in conflict. Actors need not be aware of the other's presence, thus actors may be cooperating unknowingly. This is where our definition differs from Ackoff & Emery's: both cooperation and coordination are deliberate processes between organizations. Apart form this difference, their definition of cooperation comprises both our definition of coordination and cooperation. In both cases, coordination and cooperation, the degree at which organizations attain their goal is higher than without coordination or cooperation. For cooperation in our definition the (sub)goal of the actors is the same. Concluding we may state that our definitions of cooperation and coordination are compatible with, but more restrictive than, Ackoff's definition of cooperation.

March & Simon

According to March & Simon (1959) who reference Gulick & Urwick (1937) coordination is needed for two reasons. One is to resolve conflict, the other is to guarantee cooperation (p.28). In the same work they identify uncertainty as the cause of the need for coordination, although they do not use the term explicitly: "Interdependence does not by itself cause difficulty if the pattern of interdependence is stable and fixed. (..) Difficulties arise only if program execution rests on contingencies that cannot be predicted perfectly in advance. In this case, coordinating activity is required to secure agreement about the estimates that will be used as the basis for action, or to provide information to each subprogram unit about the relevant activities of the others. (p.159)" The process of conflict resolution is in our frame of definitions called negotiation and not coordination. March & Simon do not explicitly define the notions coordination, cooperation, and conflict. Probably the difference between their concept and ours is that they perceive cooperation as a state (not stated explicitly) and not as a process as we do.

Ribbers
According to Ribbers uncertainty (about each other's actions) is not the reason for coordination: organizations may be well aware of the actions of others and may still decide to coordinate in order to improve their performance. We would state that (coupled) organizations aware of each other's actions may wish to improve their performance (see Figure 4.3). This decision in itself is not coordination. It is after this decision has been taken that the uncertainty may emerge and the need for coordination may arise. Consider for instance two trucking companies that have knowledge about each other's routes: when trucks leave for what destination. They may decide to lower their cost by sharing trucks on certain destinations. It is now that the uncertainty arises: who will cover what destination? Can the departure times remain the same? It is through design coordination that this uncertainty is removed. If the demand on the trucking services is unpredictable, some operational coordination may be required. This is an example of cooperation, in which the shared goal is the joint operation of profitable shuttles to certain destinations.

Malone
According to Malone (1988) (and also Ribbers) a shared goal is needed for coordination. In our definition the only requirement for coordination is that organizations do not have conflicting goals, i.e. that organizations are in a state of consistency or cooperation. Of course organizations have some purpose of coordination in mind, but this need not be the same purpose for both organizations as is illustrated in the following example.

EXAMPLE. Producers and retailers coordinate with respect to the introduction of new products. The producer coordinates because he is interested in the effectiveness of his product introduction campaign, while the retailer is interested in an even spread of introductions and promotions. •

These separate non-conflicting (sub)goals of organizations determine the logic organization apply when coordinating. As long as (sub)goals are not conflicting this is possible. It is for this reason that coordination is only possible in case of non-conflicting goals (Mesarovic's consistency postulate).

Van Aken
According to Van Aken (1978) the cause of the need for coordination is twofold: complexity and conflict (p.139). The first reason is elaborated as follows: "A need for coordination due to complexity arises if the suborganizations are willing to cooperate in such a way that overall behaviour is satisfactory, but are not able to do so because their local information is insufficient". As insufficient information equals uncertainty we may

conclude that our cause of coordination is in agreement with the first of Van Aken's causes. The second cause of coordination are conflicting interests between suborganizations, interests that can only be aligned through (what Van Aken calls) coordination through a third party. In terms of our definition this is called arbitrage. Again we see that the differences are a matter of definition and delineation. Where our definition of coordination differs fundamentally from Van Aken's is with respect to the number of actors involved: in Van Aken's conception of coordination there is always a third party acting as coordinator, where in our case coordination can be accomplished by two actors. When only two actors are involved Van Aken calls this 'direct mutual adjustment'.

Concluding

A sharp definition of a phenomenon is a requirement in a scientific study. As the previous exercise shows there as many definitions as there are authors. Though this is not a desirable situation, it is important that each author is clear about his definition and sticks to it. Our definition has been developed with the design of interorganizational relationships in mind, rather than intraorganizational relationships. When designing a common language for design among designers is required (see section 3.1) Discussions about concepts needs to be avoided. This, apart from the fact that in science one proceeds from extant work, is the rationale for the elaboration in this section. The different processes are illustrated in the following example, which shows that all processes may be going on in a relationship between organizations. How the processes are named here is further a matter of definition.

EXAMPLE. A group of students chatting in the cafeteria about their respective assignments are *communicating* or *exchanging data*. Some of these students have to share the CAD/CAM computer (i.e. a scarce resource) while carrying out their assignments and must hence *coordinate*, i.e. they have to decide who has access to the computer at what time. The subgroup of students who must jointly design a car engine are *cooperating*, i.e. they are working on the same output, the design. Of course they have to coordinate with respect to e.g. the access to the CAD/CAM computer, or the dimensions of the different parts of the engine so that these fit together and function properly. Supposing there are different design assignments the students may have to choose from, the selection of the assignment may involve some *negotiation* among the students if they have, for whatever reason, different preferences (subgoals). •

4.2.4 Coordination in Value Adding Partnerships

As pointed out in section 3.2, in VAPs one needs to distinguish between coordination in the design phase from coordination in the operational phase. The *design coordination* is performed in meetings among representatives of both organizations during which the contract is drawn up, the procedures, messages, and shared performance requirements are agreed upon. These activities directed at achieving one single output, i.e. the VAP design, can be called cooperation. Mesarovic *et al.* (1970) refer to the design coordination as 'coordination in the large'. During the design phase of the partnership OUs can furthermore agree upon

- the variables concerning PO, T, and X that need adjustment, and
- their value ranges.

These agreements made upfront limit the relevant variables pertaining to T, PO, X as well as their value ranges, and consequently lead to uncertainty reduction for both OUs (see also Ribbers 1991). We may thus conclude that another advantage of a VAP, in addition to the conflict resolution mentioned before, is the uncertainty reduction achieved through the 'coordination in the large'.

4.3 An analysis of coordination

In the previous section we have given a definition of coordination and explained that the need for coordination arises as a consequence of the uncertainty inherent to the control problems of coupled OUs. In this section we will proceed by describing the control problem and subsequently derive the information types involved in coordination (subsection 4.2.1). A refined model of an OU resulting from this analysis, the layered organizational model (LOM) is discussed in the second subsection.

4.3.1 A description of coordination and control

As the existence of the control problems is the raison d'etre of coordination, we will start our analysis with a description of the control problem. We will focus on dyadical coordination as depicted in Figure 4.6. Two aspect systems are of importance to logistics systems: the information aspect system (IAS) and the goods aspect system (GAS). The focal concept of our modeling perspective is that the information aspect system is subservient to the goods aspect system. That is, the information aspect system should be designed in such a way that the flow of goods is optimal given certain performance requ·rements. The purpose of the information aspect system is twofold (see Figure 4.6):

(1) to *control* the goods flow internal to the OU,

(2) to *coordinate* the goods flow between OUs.

These are referred to as the control problem and the coordination problem respectively. The following analysis of control and coordination results in a typology of information within organizations.[7]

[7] As shown in Figure 4.6 the VAP responds to customer orders. This external order will result in an internal-order from the OU receiving the customer order, which is called the *superior*, to the other OU which is called the *subordinate* (see chapter three).

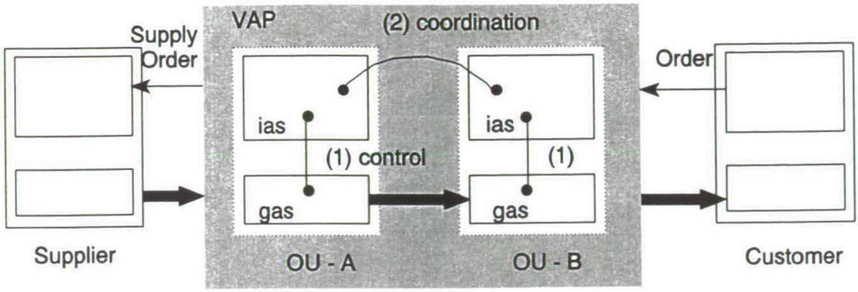

Figure 4.6 - Coordination and control

The Control Problem[8]

Consider a single isolated OU as given in Figure 4.7. Isolated refers to the fact that there is no interaction with other OUs, apart from an order and some physical input x(t). The orders, determine what the system must do, and comprise part of the OUs *goal information* **G**. The goal information may also contain a forecast which governs the GAS up till the decoupling point (see chapter three).

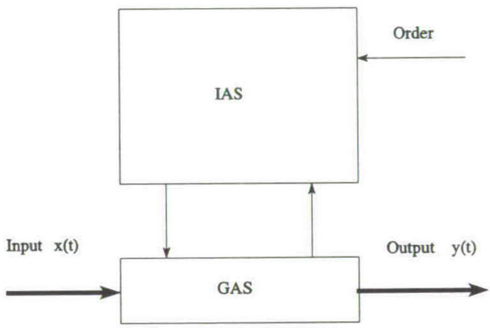

Figure 4.7 - The control setting

The first step in analyzing the control problem is the specification of the goal of the OU.

(1) **G** = {Orders, Forecast}

The control problem for the IAS is to find the *steering signals* **ss**, which determines the output y(t) of the GAS, i.e which determines the characteristics T, PO, and X of the goods flow, such that the goal information is adhered to. This may be subject to an

[8] Notice that for a single OU we only discuss a control problem. Because the IAS of the OU is treated as a black box the *(internal) coordination* between different actors/departments within the IAS is abstracted from.

additional constraint, a performance criterium **Q**, which an OU strives to attain (see chapter three). In order to make the control decision that determines **ss** the following information, apart from the goal information **G**, is needed.

(2) Status information **S** concerning the current status of the GAS.

(3) A model of the workings of the OU, $\mathbf{P} = (\mathbf{P}_G \cup \mathbf{P}_I)$, which comprises:
(a) a model on the workings of the GAS, $\mathbf{P}_G$, and
(b) a model on the workings of the IAS, $\mathbf{P}_I$.

$\mathbf{P}_G$ contains a model of the GAS, i.e. of the physical infrastructure, resources, and behavior of resources. $\mathbf{P}_I$ denotes the decision rules and procedures adhered to by the IAS, where

$$\mathbf{P}_I \leftarrow \mathbf{Q} \times \mathbf{P}_G,$$

i.e. the decision rules and procedures of the IAS are in part derived from the performance criterium and the working of the physical processes. **P** and **S** are jointly referred to as *process information*.

The information needed by the control part of the IAS is depicted schematically in Figure 4.8. That the status information affects the goal information, is denoted by a dotted relationship. This is evident, because on order which has been delivered will be removed from the goal information.

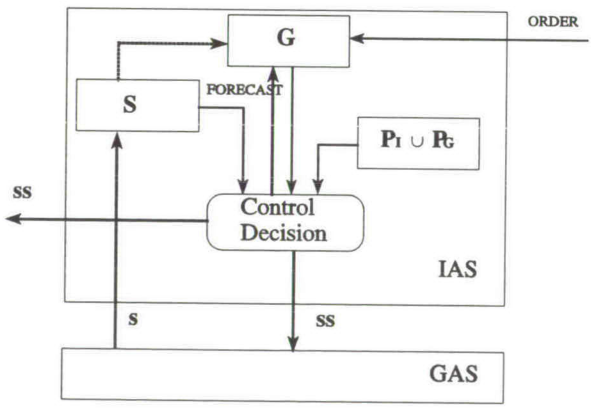

Figure 4.8 - Information used in the control problem

- *The information needed by a single operational unit for control is:*
  - *goal information, **G***
  - *status information, **S***
  - *a model of the process, **P** (which also reflects a performance criterium **Q**).*

Solvability of the control problem. A requisite for the operational solvability of the control problem is that the OU has enough alternative measures of control at its disposal (De Leeuw 1979).[9] This requisite for solvability is an application of Ashby's (1958) famous *Law of requisite variety* which states that only variety can destroy variety. It means that there must be enough variety in the measures of control, i.e. the set of steering signals **ss**, as there is variety in the orders and in the GAS.

Another way of solving the control problem is the ability to modify the goal information **G**, i.e. the customers' orders. This latter ability is delegated to the coordination problem of the OU: whether the customer orders can be changed will require adjustment of variables concerning T, PO, and X with the customer OU, a tasks which has been defined as coordination.

EXAMPLE OF THE CONTROL PROBLEM. A producer of widgets produces entirely to order and has a performance criterium **Q** concerning the waste produced. While meeting an acceptable lead time, the producer strives to stay below some maximum amount of waste in a year. The control problem is to find, given the customer orders, the best batch sizes and product sequences. The set up time and waste during set up depend on the consecutive types of widgets produced on the different machines. A model of the machines, their capacity, set up times, and waste production form the $\mathbf{P_G}$. Based on the waste production matrix of the machines and the performance criterion **Q** operating rules concerning preferred batch order of production are derived, $\mathbf{P_I}$. Steering signals to the GAS initiate the start of a particular production batch, while status signals report on the completion of batches and the amount of waste produced during setup and run time of a batch. •

We now assume that the OU just described is not isolated, meaning that it takes consideration of the surrounding OUs. We will next describe this for a pair of OUs, which 'consider each other' through coordination. Recalling our definition of coordination, and given our description of control, we may explicate coordination as the adjustment of control decision outcomes of different OUs. In order to achieve adjustment, in the design phase of the VAP conflicts between the separate performance criteria need to be resolved (the consistency postulate).

Conflict resolution prerequisite to coordination

The consistency postulate states that in order for coordination to be possible conflicts between the separate performance criteria $\mathbf{Q_A}$ and $\mathbf{Q_B}$ of respectively OU_A and OU_B need to be resolved, resulting in the non-conflicting criteria $\mathbf{Q'_A}$ and $\mathbf{Q'_B}$. This will affect the decision rules and procedures $\mathbf{P_I}$ as defined for the 'isolated OU' as $\mathbf{P_I}$ is partly

[9] De Leeuw (1979) identifies six measures for control in the broad sense, four of which are interesting in the context of this dissertation. 1) Finding appropriate steering signals. 2) Changing the structure of the system. In chapter three we discussed how second order dynamics may require such redesign. 3) Changing the system's goal, where 'goal' here refers to the activities to be performed, i.e. customer orders. Since in our case the goal is dictated by the environment, the goal cannot be changed without consulting the environment, i.e. coordinating with the customers. 4) Influencing the environment without changing the environment's structure and goal. One can think of using marketing instruments to influence customer behavior in such a manner that the resulting goal information suits the internal control problem.

determined by the performance criterium. The new rules are referred to as $\mathbf{P'_I}$ where

$$\mathbf{P'_I} \leftarrow \mathbf{Q'} \mathrm{x}\, \mathbf{P_G}.$$

In addition in a VAP a shared performance criterium, $\mathbf{Q_{IR}}$, is defined. The subscript "IR" stands for "Inter organizational Relation". Of course the separate, local, performance criteria are not in conflict with and subservient to the shared performance criterium.

Analysis of the coordination problem.
Through coordination OUs, or more precisely, the control parts of OUs, acquire knowledge about the interaction among OUs. Knowledge about events in other OUs which affect events in the focal OU are relevant for the focal control problem. Given the preceding analysis of control, we derive that a focal control problem is affected either through an effect on its status information or on its goal information. We may conclude that lack of knowledge about the interaction with other OUs manifests itself as *lacking* or *imprecise* goal **G** or status **S** information in the focal OU. We have referred to this as operational uncertainty in Figure 4.3 and will elaborate on this concept in the next section.

Coordination strives at reducing the amount of lacking or imprecise information, i.e. uncertainty. Now consider two interacting OUs (see Figure 4.9).

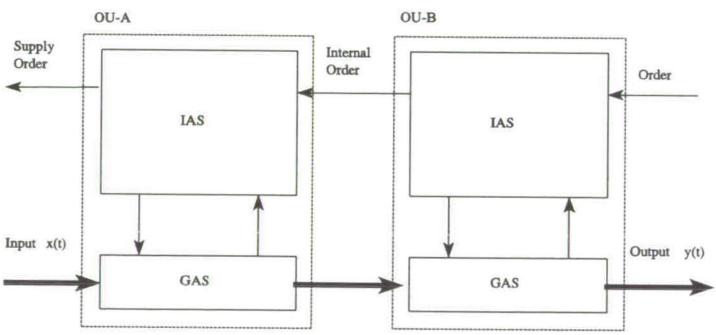

Figure 4.9 - An example of the coordination setting in a dyad

Apart from the information needed in the control problem described above (**G,S,P,Q**), the information aspect system of each OU needs to have some information on the interaction with the other OU (see Figure 4.10 for the IAS of a coordinating OU). This information is called *coupling information*, **U**, comprising:
- the 'model' of the processes in the other OU, $\mathbf{U_p}$
- the status of the processes in the other OU, $\mathbf{U_s}$
- the goal of the other OU, $\mathbf{U_g}$.

Having information, coupling information, on the control problem of another OU, is not sufficient: the focal OU will not be able to translate this into his own goal **G** or status **S** information. Hence a model $\mathbf{P_C}$ is needed which allows for this translation:

$$\mathbf{P_C} \times \mathbf{U} \rightarrow \{\mathbf{G}, \mathbf{S}\}.$$

Depending on the VAP design a mix of coupling information will be exchanged, and most likely not symmetrically, between the OUs. The information on the process of the other OU, $\mathbf{U_p}$, will be exchanged in the design phase of the value adding partnership, and will be semi-static, resident information, as will $\mathbf{P_C}$. If changes in $\mathbf{U_p}$ occur during VAP operations this needs to be communicated. The coupling information components on goal and status ($\mathbf{U_g}$ and $\mathbf{U_s}$) are more volatile in nature and will be exchanged throughout VAP operations.

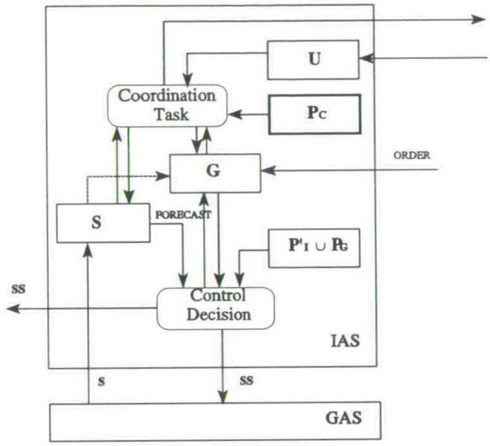

Figure 4.10 - Information used by a coordinating OU

EXAMPLE OF INFORMATION TYPES IN COORDINATION. Consider two OUs, a manufacturer of cars and his supplier of car seats, who have solved the coordination of goods flow between them as follows. The manufacturer gives the supplier the following coupling information, **U**:

- the production schedule for Car type A and Car type B over a given period, $\mathbf{U_g}$
- the relevant part of the Bill of Material for the cars, $\mathbf{U_p}$:
  - car type A contains a.o.: 2 of seat V and 1 of seat Y;
  - car type B contains a.o.: 2 of seat Z and 1 of seat Y.

The manufacturer and his supplier have agreed on the procedure that the seats should be delivered in the exact amounts three hours before a car is scheduled for assembly, $\mathbf{P_C}$. They have also agreed that this delivery time must be met in at least 99% of all deliveries, $\mathbf{Q_{IR}}$ (they thus form a VAP). In this illustration EDI plays an important role in the exchange of the coupling information. Especially for the volatile component $\mathbf{U_g}$, EDI may enable a higher frequency of exchange and hence a shorter planning period. But also the coupling information on the process model, $\mathbf{U}_p$, is very susceptible to exchange via EDI because of its need for accuracy and often also for the need for rapid communication of its updates to the other party. •

4.3.2 The layered organizational model

Given the preceding description we may discern several layers in an OU. Within the IAS there are two layers containing tasks (i.e. active layers). One for dealing with coordination, i.e. the exchange and interpretation of coupling information, and the execution of decision rules, the other layer performing the control. The data administration layer is a passive layer which models the information available in an organization, and can be partitioned according to the information typology just described. Within the GAS an active layer models the physical tasks, while a passive layer models the resources, inventories, and infrastructure. The resulting layered organizational model is depicted in Figure 4.11.

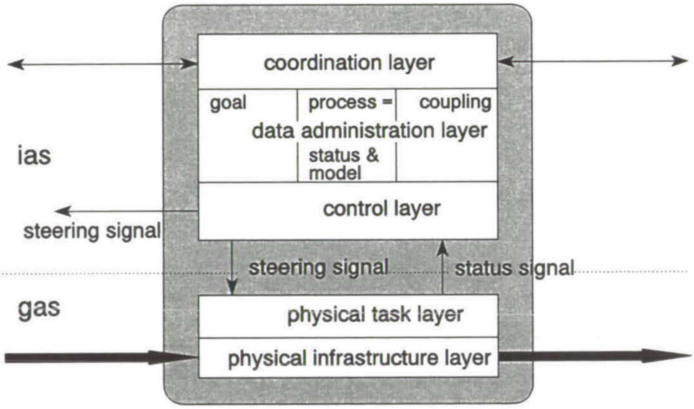

Figure 4.11 - The layered organizational model

4.4 Reducing uncertainty through coordination

In this section we take a closer look at operational uncertainty, which has been identified as a precursor for the need of operational logistics coordination. We will also describe the aspects of coordination mechanism. As will be shown *a particular coordination mechanism is a major determinant of the performance of a VAP through its impact on the uncertainty the OUs in the VAP have to cope with.* In subsection 4.4.1 the level of analysis is that of the VAP as a black box (thus of a single OU) in order to treat the concept of uncertainty. The VAP is opened in second subsection 4.4.2, at which point coordination re-enters the discussion. In subsection 4.4.3 the aspects of a coordination mechanism are presented and their relation to uncertainty discussed. Section 4.4.4 summarized the theory. Finally in section 4.4.5 the design trade-offs implicated by our theory are discussed.

4.4.1 Uncertainty

It is necessary to distinguish between two types of uncertainty:
- uncertainty as in lack of knowledge regarding the occurrence of events, and
- uncertainty as in not knowing how to respond to an event when it occurs.

Daft & Lengel (1986) give an overview on the literature pertaining to these two types of uncertainty. We refer to the first type of uncertainty as *uncertainty*, while the second type is called *equivocality*. Terms with a similar meaning as equivocality are task analyzability (Perrow 1967), and unstructuredness of decision making (Mintzberg et al. 1976).[10] Uncertainty hence is a measure of spread or variance in the occurrence of recurring events, while equivocality is a measure of unstructuredness of response to events. Tasks in the Strategic Decision Making Unit (SDMU) are more likely to face equivocality than tasks in the OU. For now we assume that the logistical tasks in OUs are not hindered by equivocality (i.e. no unanticipated events), only by uncertainty.[11]

Galbraith (1977, p.36-37) defines *task uncertainty* as " ... the difference between the amount of information required to perform the task and the amount of information already possessed by the organization". In case of logistics the task to be performed is the execution of an order, which results in tasks securing the availability of capacity and or goods, and tasks delivering the order (see section 4.3). Task uncertainty is a derivative of the uncertainty inherent to the environment of an open system, the *intrinsic uncertainty*. The level of task uncertainty is a matter of choice, i.e. a design variable, meaning that it is within the span of control of the business designers. What determines the task uncertainty is stated in the following assertion, which is subsequently explained.

- *Task Uncertainty of an OU is a function of the Intrinsic Uncertainty, the Required Performance, and the Internal Design.*

After Galbraith (1977) who relates uncertainty to output diversity, division of labor, and level of performance, we conceive task uncertainty as a function of intrinsic uncertainty, internal design and required performance. First we treat the three independent variables of this statement, and then the dependent variable.

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[10]Secondary references from Daft & Lengel (1986). Mintzberg, p.246.

[11] In chapter six we will discuss the case when OUs do face equivocality.

Intrinsic Uncertainty

Intrinsic uncertainty is a characteristic of the environment of an OU (or VAP as a black box). Within the environment we consider only the customers and suppliers of an OU, whose unpredictable behavior is referred to as demand uncertainty and supply uncertainty respectively. Intrinsic uncertainty is assumed here to be out of the control of an OU (see Figure 4.12). In reality this assumption may be violated, since VAPs could try to reduce their intrinsic uncertainty through coordination with their customers and/or suppliers, or through e.g. sales promotion actions, or pricing schemes and tariff structures.

- *Intrinsic uncertainty is comprised of Demand Uncertainty and Supply Uncertainty*

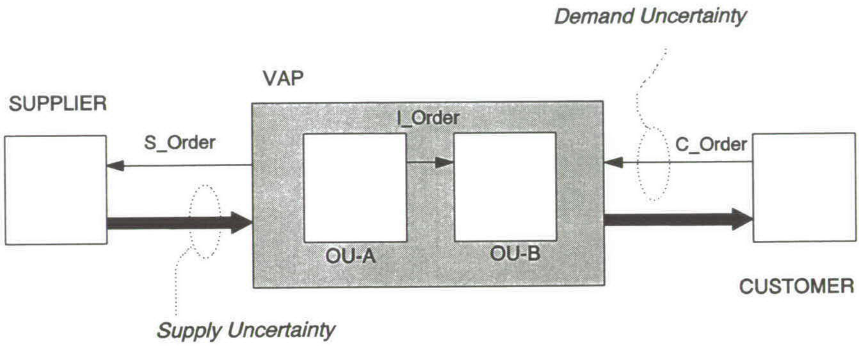

Figure 4.12 - Components of Intrinsic Uncertainty in an example VAP

Uncertainty and information are interrelated concepts, i.e. information may alleviate uncertainty, or uncertainty is lack of information. We will give an explanation of what information is and subsequently derive what uncertainty means. First the concepts of complexity and variety must be introduced, the former because it is often confused with the latter.

Complexity. There is no unified objective description of what complexity is (see e.g. Alkemade 1992, Klir 1985): complexity is in the eye of the beholder. We distinguish two types of complexity, *descriptive* complexity and *structural* complexity. The first one is related to the number of elements needed to describe a system. E.g. the description of a car 'blue corvette' is very simple, i.e. of low complexity, since only two attributes, according to the beholder are required to describe the system: its colour, and its make. The engineer who designed the car is facing structural complexity since he is interested in the structure of the car and hence is dealing with a more complex system, e.g. numerous elements (parts) which interact in a predetermined manner. If the interaction between elements is not that predictable as it is for a car, then the system is considered even more complex. The following definition summarizes this paragraph.

Definition

(a) *Descriptive Complexity is a function of the number of elements needed to describe a system to a certain observer*

(b) *Structural Complexity is a function of the number of elements relevant to a certain observer in a system, the degree of interaction among elements, and the predictability of the interactions.*

The descriptive complexity of the internal order exchanged in a VAP equals the number of data elements in the message. An example of descriptive complexity is relegated to the treatment of variety.

Variety. Though there exists a relationship between variety and complexity, some authors wrongfully use these terms interchangeably. *Variety* as defined in communication theory and cybernetics is related to the *number of choices* one has. The following example clarifies the concept of variety and shows its difference with complexity.

EXAMPLE. Consider two products: Car Z and Car Y. Three elements are needed to describe product Z while four are needed for the description of product Y:

$Z = (z_1, z_2, z_3)$, where z_i is the ith attribute of Z
$Y = (y_1, y_2, y_3, y_4)$, where y_i is the ith attribute of Y.

The possible values of these attributes are given in the table below. The choices of attribute values are independent of each other, and we assume that all values of an attribute have equal probability of being chosen.

Table 4.1 - Product specifications

Product Z		Product Y	
<u>Attr.</u>	<u>Value</u>	<u>Attr.</u>	<u>Value</u>
z_1:	yellow, green	y_1:	yellow, red
z_2:	1.3, 1.6, 1.8, 2.0	y_2:	1.8, 2.0
z_3:	liftback, sedan, station	y_3:	liftback, station, sedan
		y_4:	with, without powersteering

Since the description or specification of product Y requires more elements, the product is considered more complex than product Z. Both descriptions allow us to define 24 different variations or choices of each product, and are therefore of equal variety. •

Message variety. The above example roughly illustrates the concept of *product* variety. Drawing from information theory (see e.g. Boekee & van der Lubbe 1988) we will next give a precise description of message variety and use this later to define uncertainty. Suppose there exists an ensemble of messages, *M*, of which the messages have m attributes, i.e. $M = (a_1,\ldots,a_m)$, $M \epsilon \mathcal{M}$. Each attribute of M can take on several values, i.e. $a_i \epsilon \{a_{i1}, a_{i2}, \ldots, a_{in_i}\}$. Now suppose that the attribute values a_{ij} have non equal probabilities p_{ij}. E.g. part of M contains the specification of a car and the demand for yellow cars is higher than the demand for green cars. We may use Shannon's (1949) description of variety per message attribute a_i:

$$V(a_i) = - \sum_{j=1}^{n_i} p_{ij} \, {}^2\log p_{ij} \tag{1}$$

with p_{ij} the probability of the attribute a_i's jth value a_{ij}, $i=1,\ldots,n_i$

and $\sum_{j=1}^{n_i} p_{ij} = 1$.

The total message variety, V(M), assuming that the choice of attribute values is independent (inter attribute covariance equals zero), is the sum of the attribute varieties:

$$V(M) = \sum_{i=1}^{m} V(a_i) \tag{2}$$

with $i=1,\ldots, m$; $m=$ the number of attributes in a message.

Information and variety. Opposed to variety which is an objective measure describing a message ensemble $\mathcal{M}$, information is a measure relative to the subject being informed. In Ashby's (1958) words: "... information is not an intrinsic property of an individual message". We denote the information conveyed by a particular message M' out of the message ensemble $\mathcal{M}$ as H(M'). Suppose that the receiver has acquired some pre-information $H_{pre}(M')$ about this message M', e.g

$$H_{pre} = \sum_{i=1,3,6} V(a_i) \tag{3}$$

with a_1, a_3, and a_6 the attributes of the message already known to the receiver.

Given the variety of a message, V(M), the following equality holds:

$$H(M') = V(M) - H_{pre}(M') \tag{4}$$

According to the above description, information thus reduces the number of environmental attributes of which the receiver does not know the value. The larger the variety in values possible for a certain attribute, the larger the information one receives when one is told what value that attribute holds. (This is why variety and information can be part of the same equation.)

Notice that $H_{pre}(M')$ is the information either conveyed by an earlier version of M' or an observation made by the receiver himself. Thus the possibility that the receiver already has information about some of the attributes contained in the message, accounts for the fact that the information conveyed by a message may be less than the variety contained in the message, $H(M') \leq V(M)$. Another reason why this inequality may hold is that the receiver is not interested in all of the attributes in M', i.e. not all attributes of M' convey information. This will be elaborated upon when we discuss the concept of task uncertainty.

EXAMPLE. In the previous example M_Z and M_Y have equal variety and thus convey equal amounts of information, assuming that the receiver has no pre-information about either message. Building on that example, consider the situation in which the receiver of M_Z already knows (as a consequence of pre-information) that the first attribute of the product to be ordered is "yellow". He therefore is only uncertain about the content of the order with respect to the second and the third attribute. Hence the number of variations that can be expected is reduced by the pre-information from 24 to 12. Upon receipt of the order, e.g. M_Z(yellow, 1.6, sedan), less information is conveyed when compared to the previous example. Notice that the variety, which is a fixed attribute of a message is the same as in the previous example. •

Now that the concepts of information and variety are explained, especially the relationship between them, the concepts of demand and supply uncertainty can be treated in some depth.

Intrinsic Demand Uncertainty. Above the product variety and the information conveyed by a message that may partly contain a product specification have been discussed. Be aware that H(M') denotes the uncertainty about M', or the uncertainty reduction upon receipt of M'. If M' represents an order (from a customer) the uncertainty discussed is the demand uncertainty. Product variety is only one contributor to the intrinsic demand uncertainty. The other contributor is the timing of messages. For didactical reasons first of all identical messages (orders) are assumed, i.e. no product variety. Secondly the timing contributor is discussed in terms of the number of messages to arrive in a certain time interval. (We could also have chosen to discuss this contributor in terms of the time lapse till the next message arrival).

The number of orders to arrive in a certain period [0, L] has a certain probability. Figure 4.13 shows two probability density functions (pdf's) of demand. Pfd-2 has a larger variance λ than pdf-1 which means that there is a larger region of messages M which have a non-zero probability of occurring, which makes the prediction of the number of orders to arrive in period [0, L] more difficult. We thus conclude that the intrinsic uncertainty is higher if demand has pdf-2 instead of pdf-1.

Now the assumption of identical orders, i.e. no variety within orders, is dropped. This means that the pdf of Figure 4.13 has to be divided into x separate pdf's: one for each of

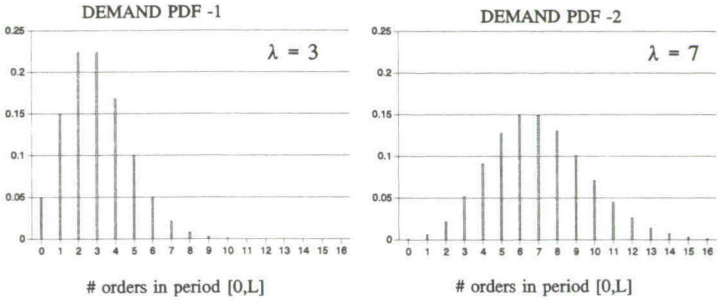

Figure 4.13 - Comparison of IU_D for different pdf's: IU_D-1 < IU_D-2

the x product versions possible.[12] It is easy to understand that dealing with x pdf's rather than one increases the difficulty of prediction and hence the uncertainty. Another line of reasoning to arrive at the same conclusion is the following. The larger the variety of orders, i.e. the larger the variety in the products ordered, the larger the information possibly conveyed by an order (see eq.(4)), the larger the intrinsic demand uncertainty.

- *Intrinsic demand uncertainty is a combination of the predictability of demand and the product variety.*

Intrinsic Supply Uncertainty. The reliability of the supplier to the VAP determines the intrinsic supply uncertainty, IU_S. This is comprised of a.o. the deviation in the lead time promised by the supplier from the actual lead time, or more generally the reliability of deliveries with respect to the variable time. Also contributing to the supply uncertainty are the deviation of actual quantities delivered from the quantities ordered by the VAP, and the deviation of the actual quality from the required quality. Just as with the intrinsic demand uncertainty, the larger the spread in deviations of the lead time (delivery reliability), or the quantity delivered, or the quality of the goods delivered, the larger the intrinsic supply uncertainty.

- *Intrinsic supply uncertainty is a function of the reliability (i.e. predictability) of delivery time, quantity delivered, and quality delivered.*

Required Performance and Internal Design

The required performance of an OU is often dictated by customers demand for a certain level of service. The variables by which performance can be measured are many, but restricted to cost, delivery reliability, and lead time in this study (see chapter three for a discussion on logistical performance measures). The required performance is reflected by norms set for the different performance measures that the OU strives to achieve.

[12] Be aware that this in not a linear division, but one which depends on the probability of the attributes, p_{ij}, that constitute the product specification (see eq.(1)).

The internal design is simplified to the location of the decoupling point (DP)[13], the level of inventory in the DP, the capacities before and after the DP, and the net production time after the DP (see chapter three). If the OU has no DP (e.g. OUs that source and produce to order, or service OUs) the internal design is just the capacity of the OU. That the required performance determines the internal design is illustrated by the following assertions.

- The required lead time is one of the determinants of the location of the DP, and the level of capacity after the DP.
- The required delivery reliability is one of the determinants of the level of the DP, and also the location if the delivery reliability is positively correlated to the lead time (the longer the route, the higher the variability). The required delivery reliability also determines the levels of resources before and after the DP.
- Cost is determined by the location and level of the DP, and the levels of capacity. The closer to the market the more valuable the products, and the higher the risk (and hence cost) of obsolescence. The higher the stock and capacity, the higher the cost.

■ *Required Performance is the prime determinant of the Internal Design*

Task Uncertainty

After Galbraith (1977) we use the following definition of task uncertainty.

> *Task uncertainty is the difference between the amount of information possessed by an organization and the amount of information needed to perform its task.*

The level of task uncertainty is chosen, i.e. the task uncertainty is a design variable. Galbraith's theory proceeds by stating that the organization form must subsequently be designed such that the information processing capacity during task execution (what we refer to as the operational phase) must match the task uncertainty. The key concept of his contingency theory is that task uncertainty accounts for the variation in organizational form. In case of a mismatch between task uncertainty and processing capacity, "reduced performance through budget overruns, schedule overruns, etc. will occur in order to bring about equality" (Galbraith 1977, p.55).

We define task uncertainty as the remainder of the intrinsic uncertainty an organization faces after it has been designed. This residual is jointly determined by the required performance and the internal design. The required performance determines which of the variables of external events are important to be predicted, and it also determines as reflected in the internal design, the levels of slack (capacity and material). The required performance (RP) constrains the solution space for the internal design (ID) but does not

[13] This concept was introduced in chapter three, and is the point in the process before which the process is governed by forecast and after which the process is driven by customer orders.

necessarily determines a unique ID. The resulting TU depends on the chosen ID, which may vary given a certain required performance:

$RP \rightarrow ID^1 \rightarrow TU^1$
$RP \rightarrow ID^2 \rightarrow TU^2$, where TU^1 may not equal TU^2

If the OU sets high targets on logistical performance, it must make accurate predictions of its environment. The task uncertainty depends on the quality of these predictions, which in turn depends on the *willingness* (due to economic reasons) and *ability* to make accurate predictions (Donselaar 1989, Simon 1977).

During operations task uncertainty is *matched* by (see Figure 4.14):
(1) coordination with the environment,
(2) deviation from required performance (lead time and delivery reliability),
(3) cost of emergency measures.

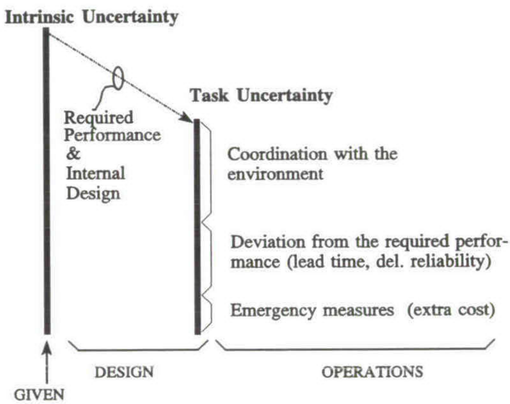

Figure 4.14 - Task Uncertainty as a design variable and its implications

Notice that equivocality does not contribute to the task uncertainty of the focal OU. Consider for instance the situation in which in a certain period an OU has received ten orders, but has capacity for the delivery of only six. The level of capacity was chosen during design and is in accordance with the required performance. The OU has no rules to determine which of the ten customers are served. This is clearly a situation of equivocality as defined at the beginning of this section. Which customers are served and how this is determined does not alter or add to the three components by which task uncertainty is matched during operations.
Because of the intrinsic uncertainty the OU designer needs to make predictions about the levels of capacity and goods of the internal design that will suffice. Often the internal design will contain some slack (safety stock and safety capacity) to deal with the intrinsic

uncertainty. The fact that the OU must make predictions is evidence of the fact that it faces task uncertainty. Task uncertainty can be operationalized as the probability that a prediction will not suffice (see also Donselaar 1989).

The following examples give an illustration of task uncertainty. If we assume that there is no intrinsic supply uncertainty ($IU_S=0$), we may use the first example to support the relationship depicted in Figure 4.14 that the task uncertainty is less than or equal to the intrinsic demand uncertainty ($TU \leq IU_D$). The second example illustrates the impact of the intrinsic supply uncertainty on the task uncertainty.

EXAMPLE. Consider the example of Table 4.1. The colour attribute of a message may not be relevant since there is more than enough inventory of paint in all colours. Task uncertainty (TU) is thus reduced at the expense of performance, in this case (inventory) costs. It also possible that the 'motor' attribute of an order is not relevant, since the motor is ordered from a supplier on receipt of a customer order: no need to make predictions for this attribute, hence lower TU. Since the production process has to wait for the motor from the supplier, TU is reduced in this case at the expense of the customer lead time (i.e. performance). ●

EXAMPLE. If the supply time of the motor varies over time, there exists intrinsic supply uncertainty. Depending on the lead time and spread therein agreed upon with the customer this IU_S will contribute to the task uncertainty. If the spread in supply lead time is much smaller that the spread in lead time the customer is willing to accept, IU_S will probably not contribute to the TU. If, however, the spread in supply time is much larger than the acceptable spread in customer lead time, the OU will, even if there is no demand uncertainty, try to predict the supply time and order earlier (time slack) than would be necessary if IU_S were zero. This need to predict implies the existence of task uncertainty. ●

The level of task uncertainty is *set* by the choice (prediction) of levels for capacity and material. It is the residual of intrinsic uncertainty faced by the OU. As we have assumed that coordination with the environment is not possible, this residual will result either in (see Figure 4.14):

(1) a deviation between required performance and actual performance;
(2) extra cost for the OU because of emergency measures it takes in order to meet specified T, PO, and X (e.g. using air transportation instead of the normal transportation by ship). This option is referred to as *supplementing of the missing* (In 't Veld 1990, p.60).

4.4.2 Opening up the dyad: the emergence of boundary uncertainty

Hitherto the VAP has been viewed as a black box (as if it were a single OU). In opening up the black box two other sources of uncertainty emerge. The first source is the uncertainty in the goods aspect systems of the OUs (see Figure 4.15), e.g. machine break downs, unpredictable queuing behavior in job shop production systems, unexpected delay in transport due to traffic congestion. This is referred to as GAS uncertainty (GU). Another source of uncertainty which is omitted here, is the uncertainty in the information aspect system due to e.g. typing errors.

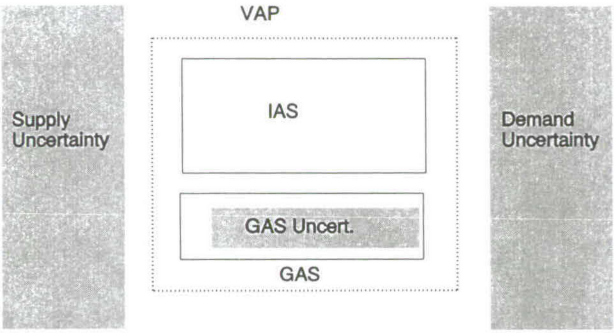

Figure 4.15 - Opening the VAP(1): GAS uncertainty

If next the boundary between OUs in the VAP is introduced a second source of uncertainty emerges (see Figure 4.16): boundary uncertainty (BU).

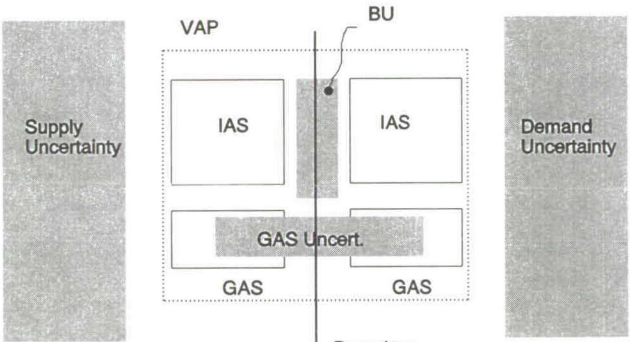

Figure 4.16 - Opening the VAP (2): Boundary uncertainty (BU)

The boundary uncertainty arises because OUs lack information regarding each other's status and action, and because the observation of the environment is split. The latter means that in general the superior OU observes (knows about) customer behavior, while the subordinate observes supplier behavior. It is this boundary uncertainty that can be matched by tighter operational coordination in a dyad. The boundary uncertainty can be divided into an *internal demand uncertainty* for the subordinate and an *internal supply uncertainty* for the superior. A chosen coordination mechanism may affect one or both of these constituents of boundary uncertainty. For instance, by giving the subordinate access to the superior's goal (orders received) and status information, the subordinate not only can anticipate the internal orders, but also gets, at an earlier stage, a sense of changing customer behavior. This will reduce his (internal) demand uncertainty. If the superior on the other hand gets insight into the goal and status information of the subordinate, he gets insight into how long it will take before the internal order is delivered, and through the status of the subordinate more information on the actual time of delivery in case the subordinate has GAS uncertainty. This may reduce the superior's (internal) supply uncertainty.

Which of the OUs faces how much of the VAP task uncertainty, which is reflected in the internal- demand and supply uncertainties, is a matter of VAP design, and is referred to as the *uncertainty transfer ratio* (UTR). In a VAP it is possible for one OU to transfer the uncertainty it faced before entering the VAP onto the partner OU in the VAP. This can be done for instance because the previous OU is more powerful than the latter OU. Uncertainty will also be transferred because the latter OU makes dealing with uncertainty its core business. We only mention the notion of UTR, and assume a certain UTR a given in our study. It is beyond our scope to describe how this ratio is determined. An illustration of how internal demand uncertainty may be affected by GAS uncertainty is given in the next example.

EXAMPLE. Consider a truck manufacturer who has subcontracted the coach work to a car body manufacturer with whom he has a VAP. On receipt of a customer order, the truck manufacturer sends an internal order to the body manufacturer. Before the chassis is shipped to the body manufacturer, the truck manufacturer needs to make some customer specific adjustments to it. As the lead time of these physical adjustments is highly variable due to tight capacity at the truck manufacturer, the body manufacturer faces extra internal demand uncertainty, since he does not know exactly when his internal order, the chassis, will actually arrive. The message called internal order can be looked upon in this case as pre-information. •

4.4.3 Operational coordination mechanisms

In chapter three we pointed out that the *type* of the coordination mechanism in a VAP is predominantly the *standardization of process* type. In this section the concern is with determining how the standardization of process type of coordination is accomplished operationally, i.e. with describing the aspects that may be distinguished within the activities that accomplish operational coordination. Taking the definition of coordination as our point of departure, two *aspects* of coordination mechanism are postulated, followed by some illustrations. Just as Mintzberg and Galbraith postulated their coordination mechanisms, so will we. Therefore, although the following expose is semi-structured, no proof of completeness, i.e that all aspects of coordination mechanism are found, can be given.

The purpose it to find several design aspects of coordination mechanisms, and give some examples of these, without trying to come up with an exhaustive set of basic designs for the aspects. Our line of reasoning is structured along four steps.

(1) Coordination is required to reduce uncertainty pertaining to the interaction with the other OU, hence about the internal order, I.O., and delivery of that order, or any event that leads to the placement of the internal order or its delivery. The superior sends the internal order to the subordinate, which (generally) replies by sending an internal report, I.R. The internal report may contain a more exact specification of variables pertaining to T, or of combinations of T and PO. (We assume that the superior will fully specify the variable place, X.)

(2) Recalling (see section 4.1) that coordination is defined as "... the timely ... adjustment of decisions in different OUs with respect to the variables pertaining to T, PO, and X ...", the coordination mechanism is the mechanism by which this *adjustment* is obtained. What has adjustment to do with the uncertainty reduction of the previous step? The fact that the variables of an internal order are determined together - through adjustment - reduces the uncertainty for the subordinate with respect to being able of meeting the order, and hence reduces the uncertainty of the superior with respect to the delivery of the order.

(3) If the coordination decision which determines the variables pertaining to T, PO, and X of an internal order or internal report can be described as

D_i: $V_i \rightarrow M_i$,

with $m_i \in M_i$, m_i = set the value of variables pertaining to T, PO, X of I.O., or
m_i = set the value of variables pertaining to T, PO, X of I.R.;
D_i = the decision rule that is applied by OU_i
V_i = the information available to OU_i.

then the following characteristics may be discerned:

- the subscript i: the OU making the decision
- V_i: the information on which the decision is based
- D_i: the decision rule
- m_i: the action resulting from the decision.

(4) Based on these characteristics we now postulate the following two aspects of coordination mechanism:

- The *decision making aspect*. Which OU determines the variables of the internal order or internal report? And, what decision rule is applied?

- The *communicating aspect*. On what information V_i is the decision based? Does the OU_j have insight in V_i, i.e. in the events leading to the decision? How are the decision outcomes m_i (e.g. internal orders and reports) exchanged?

- *There are two aspects of coordination mechanism: the decision making aspect and the communicating aspect*

If the superior decides on all variables (pertaining to T, PO, and X) of the internal order, and bases this decision only on his own information, i.e. V_{SUP} does not contain coupling information, we have one extreme design of the aspects of coordination mechanism. If fact this extreme contains no operational coordination. The reader should keep in mind that although the superior dominates the decision making operationally, the coordination mechanism has been endorsed by *both* parties in the design phase.

The extreme design of both aspects at the other side of the spectrum, is the case in which all information is shared among OUs, and in which all decision rules are shared. This results in perfect coordination: each OU knows as much about the environment as the other, and each OU can calculate the other's action. In this case all boundary uncertainty withers and it is as if the VAP is a single OU. Of course the task uncertainties in both OUs as a consequence of the GAS- and intrinsic uncertainty remains. Examples of coordination mechanism in between these extremes are given next.

EXAMPLES OF COORDINATION MECHANISMS

(a) The superior fully decides on the variables pertaining to T, PO, and X, but the subordinate has access to the superior's database and knows his decision rule that determines the internal order. This access allows the subordinate to anticipate the order and hence this reduces his internal demand uncertainty.

(b) The superior takes the load and status of the subordinate into consideration when he determines the variables pertaining to T, PO, and X. This makes it more likely that the subordinate can execute the order correctly, which subsequently reduces the supply uncertainty for the superior.

(c) The variables are determined jointly. The internal demand uncertainty for the subordinate is lowered by the fact that he is allowed to determine the internal supply time. •

EXAMPLE. Illustrating how Q_{IR} may lead to more variables to be adjusted. A warehouser and a transporter have a partnership, in which agreements with respect to the availability of transport capacity have been made. The transporter picks up the goods at the warehouse, which are usually several truckloads, and transports them to a sorting centre where the trucks are unloaded and the shipments are sorted per destination. From the sorting centre the newly loaded trucks leave for the final destinations of the goods. The warehouse informs the transporter when he has to pick up how many goods. So there is coordination with respect to time, t, and the volume of the physical object, PO[volume]. Now consider that the warehouser and transporter wish to reduce the delivery time, which becomes a shared performance index. They do so by speeding up the sorting process. The transporter provides the warehouser with a preferred sequence of goods ($\mathbf{U}_p$). The warehouser uses this information in his picking process to determine the sequence in which he loads the goods in the trucks. So we see that because of the extra shared performance index (or extra tight norm for an existing performance index), delivery time, the OUs add an additional variable to their coordination, which is the order of the goods, PO[sequence]. •

4.4.4 Recapitulation

Organizations, and also VAPs, are swimming in a sea of intrinsic uncertainty. How this uncertainty affects them is matter of design choice, and often dictated by the customer. The uncertainty that affects the organization is less than intrinsic uncertainty and is called the task uncertainty. No task uncertainty means either that there is no intrinsic uncertainty, or that uncertainty has been traded off for slack. The task uncertainty of an OU in a VAP consists of part of the task uncertainty at VAP level, GAS uncertainty, and boundary uncertainty. This boundary uncertainty results from OUs having uncertainty about the actions of the other OU. Action, M, in an OU is determined by its decision rules, D, and the state of the information aspect system, V. In a VAP EDI can be used to reduce boundary uncertainty, i.e. improve coordination, through more intensive information exchange, enrichment of V (the communicating aspect) in combination with more shared decision rules, D (the decision making aspect). The relationships between units in the previous subsections are summarized in Figure 4.17 below.

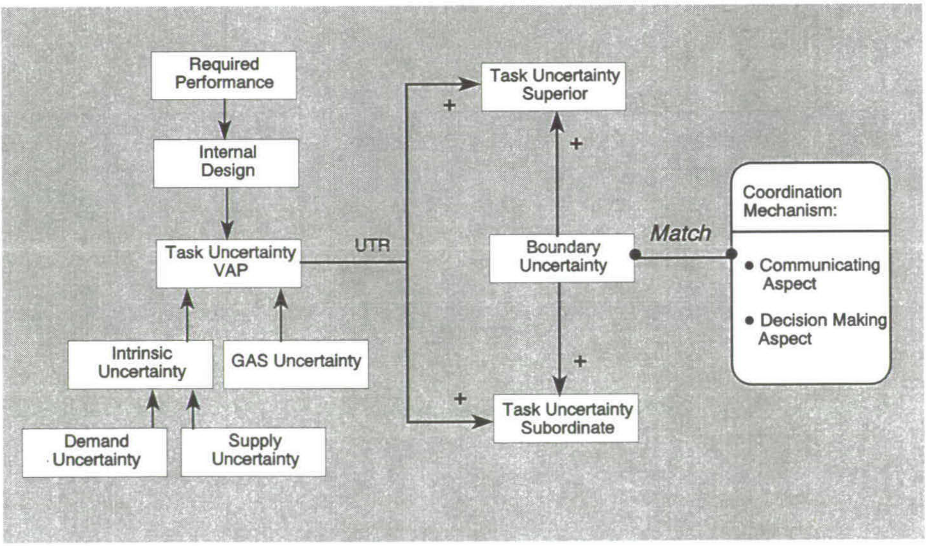

Figure 4.17 - Relationship between concepts

4.4.5 Theoretically implicated trade-offs for the business designer

The objective of our study has been to gain knowledge that will enhance the design of VAP operations (see section 1.4.1). The theory of logistics coordination is knowledge that will enhance the design process through the insight that it yields, and as such fulfils the objective set out at the beginning of this study. In this section we will emphasize that our theory of logistics coordination bears within it design variables and their interrelationships.

A model of decision making in design

Design is modelled as the process which takes a situation O and transforms it into situation N. The process consists of two phases: conceptualizing the new situation O and implementing the new situation.[14] The design will reach its implementation only if the following relation holds (over a certain time horizon):

$$(\text{(Benefits of N)} - \text{(Benefits of O)}) \geq \text{Cost } (O \rightarrow N) \tag{5}$$

where Benefits = Return - Cost
O = the old situation/design
N = the new situation/design
Cost (O→ N) = Investment

This means that the business designer needs to be able to appraise the old and the new situation.[15] We will next discuss the design variables that make up a situation, followed by a description of the trade-offs between design variables. A similar emphasis on design variable interaction for the design of logistics chains can be found in INRO-TNO (1994).

Design variables

Recalling Figure 4.14 the design variables that a business redesigner should take into account are (see Figure 4.18):

- the (amount and) cost of coordination, CC
- the cost of the internal design, CID
- the cost of deviations from required performance, CDEV
- the cost of emergency measures, CEM.

Design is about finding the values for variables where the following objective is reached:

$$\text{minimize } (CEM + CDEV + CC + CID) \tag{6}$$

The cost of the internal design (CID) comprises the costs of inventories in the dyad and the costs of capacity. The cost of emergency measures (CEM) depends on the measure itself and the probability of the occurrence of an event that calls for that measure. The cost of coordination (CC) is the cost of exchanging information in the operational phase plus the cost associated with the processing of the information (the cost of the coordination layer in the layered organizational model). The cost of deviation from the

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[14] We deliberately simplify the design process here and refer the reader to chapter two for more elaborate models of design and decision making.

[15] It is beyond the scope to include the uncertainty and risk involved in making appraisals of investments. The reader is referred to the literature on the subject (e.g. George *et al.* 1991, Morley English 1968).

required performance (CDEV) is the most difficult to quantify.

$$\text{CDEV} = \text{F}\ (\Delta \text{ lead time}, \Delta \text{ delivery reliability}) \tag{7}$$

where Δ denotes the deviation from the required performance.

The function F depends, among other factors, on customers' response to a diminished or improved lead time and/or reliability. Will an organization loose or gain customers given a certain deviation? How is this measured in guilders? The function F is really an entrepreneurial function. Although difficult to quantify, the CDEV must be included in the evaluation of an alternative design.

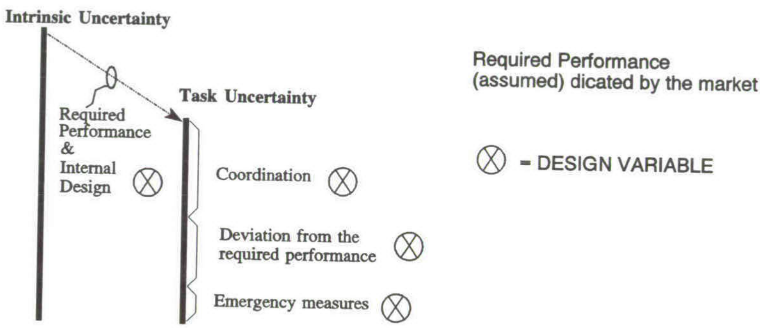

Figure 4.18 - Design variables embedded in logistics coordination theory

The trade-offs between the design variables are:
- the trade-off between (internal design) and (coordination, deviation, emergency measures)
- the trade-off between (coordination) and (deviation) and (emergency measures).

As coordination is the prime variable of concern, the trade-off between coordination and the other variables is summarized in Figure 4.19. After Emery (1967) the costs incurred by the other design variables are collectively referred as the cost of independence.

$$\text{Cost of independence} = \text{CID} + \text{CDEV} + \text{CEM} \tag{8}$$

Figure 4.19 shows that one may interpret the Cost of independence as the return of coordination.[16]

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[16] Notice that the cost of design coordination is included in Cost (O $\rightarrow$ N). There exists a trade-off here as well between Cost (O $\rightarrow$ N) and CEM as was discussed in chapter six. We will refrain from this trade-off here.

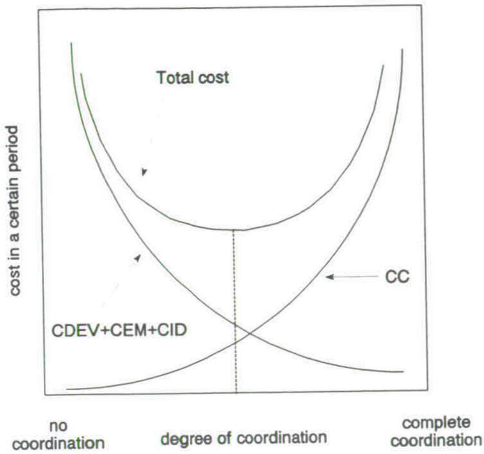

Figure 4.19 - Trade-off between coordination and 'independence'

Recalling that the cause of coordination in a VAP is the boundary uncertainty between organizational units, it is easily derived that the usefulness of coordination effort internal to a VAP is bounded by the boundary uncertainty as depicted in Figure 4.20.

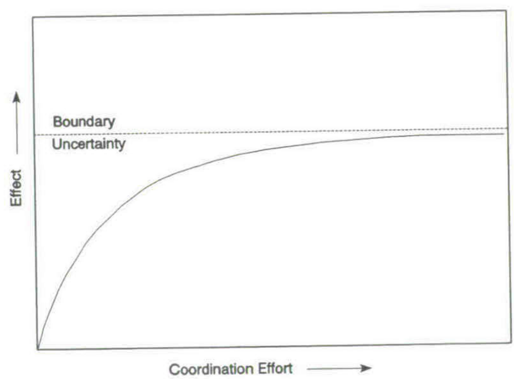

Figure 4.20 - In a VAP coordination is bounded by Boundary Uncertainty

Remarks
We already mentioned that the function F is really an entrepreneurial function. The equation (5) is furthermore highly dependent on the time-span over which the benefits are measured. A redesign that seems to be losing money in the short run, may proof to be of strategic importance in the long run. Benefits, e.g. bonding with customers, opportunities for offering new services, and costs, e.g. risk of getting locked in, have been excluded

from the preceding cost-benefit analysis. Parker & Benson (1988) recognise the importance of these 'soft' variables by making a distinction between tangible value and other classes of value for business.[17]

The costs incurred by a chosen design are rarely equally distributed over the participating organizational units. Convincing some decision makers of the overall benefit of a design, and persuading others of e.g. sharing the benefit with their partner is essential (Ruijgrok 1991, p.10). Although not discussed in this study, one must be aware that these processes may hamper the implementation of an ideal design.

4.5 EDI and its implications for coordination

In the previous sections we have obtained an understanding of coordination as the purpose of organizational communication, and uncertainty as the cause of coordination. We are now able to assess the potential effect of a new means of communication such as EDI on coordination. We are especially interested in the opportunities EDI offers to improve business performance through redesign of business processes. We are hesitant to speak about 'the impact of EDI' because literally the impact of merely introducing EDI is small, and certainly not of a strategic nature. EDI itself is becoming ubiquitous and "business as usual" (Streng 1993). As the boundary uncertainty (BU) is the main source of uncertainty to be tackled by coordination, the first issue for the VAP (re)designer becomes: "How may EDI reduce boundary uncertainty?". Secondly he must ask what changes in the logistical processes are enabled by EDI. We will approach these questions by stating EDI's capabilities, discussing their potential for boundary uncertainty reduction, discuss the relation between EDI and coordination, state two practical laws, and give directions for EDI induced redesign opportunities.

4.5.1 EDI and its direct effects

In a VAP new innovative redeployments of (physical) tasks among OUs can be managed by using EDI. Although such new designs will be of true strategic nature, it is felt that making generic statements about what new distribution are enabled is not possible. Furthermore we conjecture that EDI is not the only enabler of such new designs. We suffice by saying that changes in the lower layers of the layered organizational model which result in more intensive, i.e. more frequent and more time critical, communication patterns are favoured by the use of EDI. In subsection 4.5.5 we will use two constructs to represent the process characteristics of the lower layers. Generic statements about the relation between EDI and these constructs are possible and are relegated to that subsection.

[17] These classes of value are: strategic match, consequences of delay or competitive response, management information, competitive advantage. See Streng (1993) for an application of this typology to several EDI projects.

We restrict the following analysis to EDI as a means of communication internal to the VAP. Whether EDI is used between the VAP and its environment has no bearing on the following expose. The intrinsic attributes which distinguish EDI from more conventional means of message exchange in our study are its *speed* and *reliability*, and the relatively low *cost* at which these can be obtained (assuming sufficient message volume).[18] The reliability becomes higher because of the elimination of data entry and the errors made therein. These could be called a source of IAS uncertainty. The 'ease of data capture' attribute which was also mentioned in section 1.2 is especially relevant in market usages of EDI. It makes the collection of information from many actors in the market possible in order to arrive at better founded decisions, e.g. in price shopping. For our purposes the 'ease of data capture' attribute is considered part of the cost attribute. Often attributed to EDI is its standardization attribute, i.e. the use of industry wide standardized messages. Just as with the previous attribute, this attribute is not of interest in dyadical VAPs, where it is irrelevant whether the organizations use either standardized or proprietary messages.

- *The intrinsic attributes which distinguish exchange by EDI from conventional message exchange are speed, reliability, and cost.*

Ideally, with the use of EDI the speed of exchange between applications is higher, the reliability is higher, and these are obtained at lower costs than with conventional message exchange.

These attributes themselves may result in direct business performance improvement viz-a-viz the situation without EDI. The mere introduction of EDI may result in the following *efficiency improvements* (first order effects):

- the internal supply lead time in the VAP is reduced because of reduced message exchange time, and reduced message processing time, both of which are an integral part of the internal supply time;
- the internal supply delivery reliability is improved because message exchange by means of EDI is less error prone;
- the cost of information exchange and document administration is lower than for conventional message exchange (telephone, telefax, mail).

The latter of course depends on the message volume and the initial investments made in the EDI systems. In a VAP where the coordination is tight it is very likely that the message volume is so high that communication by means of EDI is cheaper than communication by fax or phone. Whether the first two improvements can be achieved depends on the internal operation of the receiver of the EDI message, e.g. buffering of messages, and reliability of GAS operations.

We thus repeat the main issue facing VAP (re)designers: "How may EDI reduce boundary uncertainty?" With the attributes of EDI in mind, some capabilities of EDI are postulated

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[18] Because we are considering EDI in the constellation of a VAP we will not mention the advantages of EDI in a normal market constellation, e.g. image, customer loyalty (switching costs), an incentive to rethink current processes, a way to get to know trading partners and improve the relationship.

(without claiming to be exhaustive) and it is explained how the capabilities may lead to boundary uncertainty reduction.

- *The capabilities of EDI are:*
  - *the sending of pre-information,*
  - *increasing the order frequency between OUs,*
  - *the sharing of data among OUs.*

Of course these capabilities are not exclusively EDI's. *Pre-information* is information preceding a goods flow (e.g. a truck loaded with goods to be stored) or an order. Pre-information may lead to concurrency in the logistical process or to anticipation. The latter means that scheduling may be improved. Concurrency reduces lead time, and shorter lead times generally lower the uncertainty. Concurrent work processes, on the other hand, in general require more variables to be adjusted. As a result more intensive communication is required, something which is well dealt with by EDI.

If the superior accumulates the customer orders over shorter periods, and increases the internal order *frequency*, the demand uncertainty for the subordinate is reduced. *Sharing of data* can be achieved by having either a shared database, which results in an ideal implementation of the notion 'sharing', or a linked database, which is the case often adopted in practice. It is required that the OUs also have some shared decision rules D_i, which enable the interpretation of the data shared. That this continuous view on each other's information reduces uncertainty is obvious. The applicability of these capabilities of course depends on the economic assessment of the cost and benefits of uncertainty reduction, i.e. coordination. This is true for every example or redesign measure discussed in the remainder of this chapter.

4.5.2 Coordination mechanism and EDI

EDI is one of the means of communication possible to exchange information between OUs. Thus, EDI may enhance the communicating aspect of a coordination mechanism. The decision making aspect of a coordination mechanism, the decision rules D_i and their sharing by OUs, are not directly affected by EDI. Indirectly they are because an enhanced information exchange may enable more elaborate information spaces V_i^{new} on which decisions can be based. Thus enabling better decision with existing rules, or improved decision rules D_i^{new}. The sharing of decision rules in VAPs is important because it allows for the interpretation of the information shared, i.e. the calculation of each other's action.

From the reasoning in the previous paragraph it follows that EDI allows for boundary uncertainty (BU) reduction through enhancement of the information exchange, and through enhancement of decisions leading to more concerted action. Stated otherwise: EDI enables more intense coordination. Building on this, two *strategies for using EDI* may be discerned.

- In the first strategy boundary uncertainty is assessed and reduced through EDI enhanced aspects of the coordination mechanism.
- In the second strategy, process innovations which improve performance are searched for. These innovations may increase uncertainty, i.e. require more knowledge about interactions. This increased need for coordination is coped with through EDI.

Both strategies are based on the premise that EDI is an enabler of boundary uncertainty reduction.

4.5.3 EDI induced redesign

EDI, through its lead time reduction and reliability improvement, leads to task uncertainty reduction. That a higher internal supply reliability leads to uncertainty reduction needs no explanation. Lead time reduction leads to uncertainty reduction, because the period over which predictions are made becomes shorter, and the prediction hence more reliable. Capitalizing on the reduced task uncertainty results in *status quo improvements* (Enkawa 1992), i.e improvements as a result of changing parameter values (e.g. batchsize) of an existing way of doing something. Towill *et al.* (1992) call this second order effect *retuning*. The capabilities of EDI that may lead to *breakthrough* improvements, i.e. breaking away from existing ways of working (the third order effects), are discussed in subsection 4.5.5. Be aware that breakthrough improvements themselves are not discussed. In our opinion these are very process specific and contingent on many more factors than just EDI. Therefore no precise rules for (re)design can be given. Instead some areas in which these breakthrough (re)designs can be rooted are outlined. The different levels of impact are depicted in Figure 4.21 along with the relevant level of assessment.

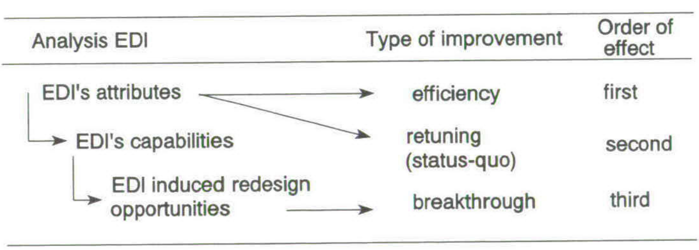

Figure 4.21 - Levels of EDI impact

The essence of EDI is that it can make more information available, either through more timely versions of existing information (higher update- or order frequency, shorter information lead time), or through new information (e.g. a partner's status information). More information is only useful if it leads to uncertainty reduction[19], be it directly (the second order effects discussed above) or indirectly, i.e. through redesign (third order

[19] Notice that we use the term 'information' in the broad sense. In the strict sense information by definition leads to uncertainty reduction, and the term 'data' would be appropriate.

effects). Whether information may lead to uncertainty reduction on the part of the receiver depends on his current level of task uncertainty, and of course on the information itself. Only information which contributes to the decision making of the receiver (i.e. which enhances V_i on which D_i operates) is worth the exchange. This remark, seemingly trivial, tends to be overlooked by business designers in the midst of their redesign process.

Uncertainty faced by the internal control problems has been identified as the main cause of coordination, and its reduction as the main purpose of coordination. Some of this uncertainty is caused by the boundary between OUs in a VAP.[20] Resulting from the analysis in the previous section is the following claim, which guides our search for EDI induced redesign opportunities:

- *Using EDI to improve coordination in a VAP requires thinking of EDI as an enabler of boundary uncertainty (BU) reduction.*

4.5.4 Two laws for design

Before deriving directions for search for EDI induced redesign opportunities, we will discuss two practical laws.

The law of diminishing returns
The higher the uncertainty an OU possesses, the higher the potential of performance improvement through improved coordination. Hence subsequent steps of uncertainty reducing redesigns are most likely to result in less improvement than previous redesign steps (see Figure 4.22). One could view this as a *Law of diminishing returns*.

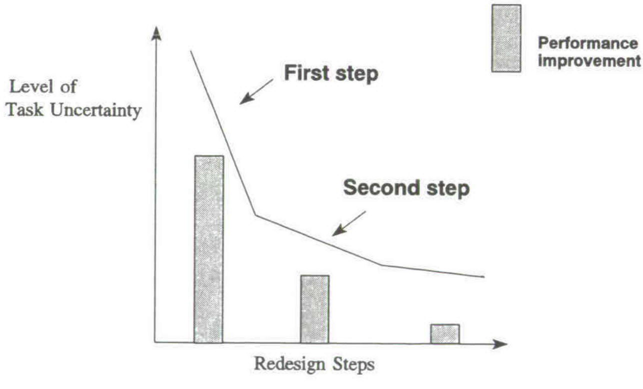

Figure 4.22 - The law of Diminishing Returns for EDI induced redesign steps

[20] Throughout the analysis given here the supply and demand uncertainty about the *environment* are assumed given and fixed, as is the GAS uncertainty. The first two may be reduced by coordination with the environment, the latter through improvement of the physical infrastructure. Although both remedies are beyond the demarcation of this study, the same principles of coordination are applicable.

An example of how the effect of EDI is less for a system with lower uncertainty is given in Enkawa (1992) for a two stage supply chain. There it is shown how the effect of using echelon stock (which is enabled by EDI) as opposed to using on-hand stock is less dramatic for small batch sizes (a 30% inventory reduction) than it is for large batch sizes (a 50 % inventory reduction). The larger the batch sizes, the longer the time interval between orderings, the higher the uncertainty faced by the supplying echelon of the chain. This higher uncertainty for large batches explains the stronger effect (of the EDI induced redesign of using echelon stock) on inventory reduction when compared to small batches.

The law of possible Variety

Consider the case of a ferry operator who has his vessels depart according to a fixed schedule. Due to tracking and tracing by trucking companies the operator gets reliable information regarding truck arrivals (i.e. orders). This uncertainty reduction in demand enables the ferry operator to move towards a flexible vessel departure schedule, with the aim of reducing average truck waiting time. If the information from the trucking companies is reliable there exists an algorithm which assures that the average waiting time is less in the situation with flexible scheduling than in the situation with fixed scheduling. What we have working here is the reverse of Ashby's Law of Requisite Variety (Ashby 1958), which states t hat "only variety can destroy variety". We call it the *Law of Possible Variety*, and formulate it as follows:

"Only variety can create variety".

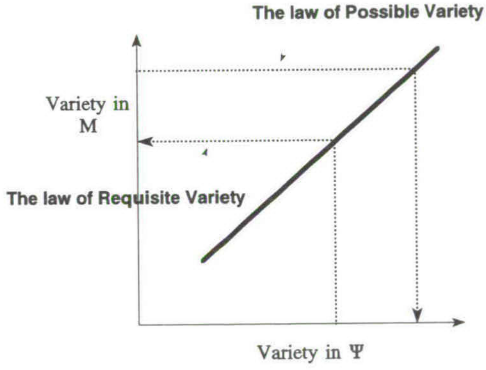

Figure 4.23 - The laws of Possible and Requisite Variety

Due to the enhanced information V_{Ferry} for the ferry operator, a variable can be added to his internal control problem, e.g. 'number of truck arrivals in the next X minutes', allowing him to make control decisions which enable more variety in the actions in the GAS. In other words, the richer the information space V_i, the more decision rules D_i are possible to produce more effective actions m_i. A prerequisite is that the variety of the action space M_i is increased, i.e. there are more actions available to the OU. The same line of reasoning applies to enrichment of V_i through more status information obtained by e.g. tracking and tracing. The laws of possible and requisite variety are different sides of the same coin as is depicted in Figure 4.23.

The increased variety in the environment and the GAS (jointly denoted by Ψ) due to the increased variety in M_i may, through the law of requisite variety, cause another OU to increase the variety of its actions, M_j. In our ferry example, for instance, the pilot service OU of the port must increase the variety of its internal control (dispatching of pilots) to cope with the irregular ferry departures.

4.5.5 In search of redesign opportunities

Ideally rules for the generation (re)design alternatives should be developed. These would be of the following structure:

> Given certain Process Characteristics,
> implement some Redesign Requirement (enabled by some EDI capability)
> in order to achieve some Performance Improvement.

Because EDI is an enabling but by far not sufficient requirement for most redesigns, it is felt that it is impossible to compile lists of such clear cut (re)design rules, based on the preceding knowledge of coordination and EDI. And even if we had full knowledge of all possible types of logistical processes, we doubt whether generic rules in the above form are possible, and maintain our position expressed in chapter two that design is partly a creative act. We do feel that the preceding theory enables us to give *directions for searching for (re)design opportunities*. The business redesigner can use them in order to assess the implications of the capabilities of EDI for his particular VAP. The process characteristics and redesign requirements are discussed.

Process characteristics
We will next discuss three process characteristics:
- the information dependency,
- the degree of freedom, and
- the variety in actions.

Information dependency
An important process characteristics is the *information dependency* (see Figure 4.24). The arrows in the diagram represent a "may influence" relationship, e.g. S_{sub} may influence G_{sup} (the arrow with label '4'). This relationship exist e.g. when a producer has subcontracted part of a job which he needs to finish himself: the time at which the subcontractor completes his task (status information) determines the time at which the producer can resume finishing the job (goal information). Redesigners can use this information diamond to assess the data dependencies between OUs. For each dependency found, they can decide on whether the information function f_i should support it, and how. This will result in a reduction of the boundary uncertainty.

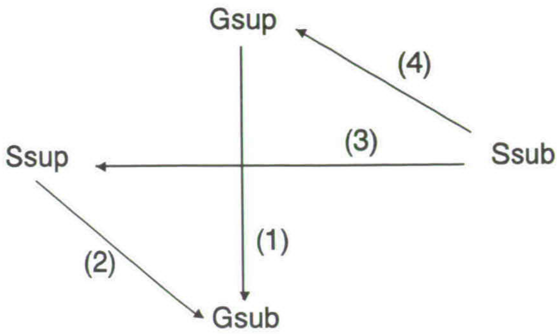

Figure 4.24 - The information dependency diamond

The degree of freedom

Another process characteristic is *the degree of freedom (DoF)*. This denotes the extent to which the variables pertaining to T, PO, and X as specified in the internal order constrain the internal action of the subordinate, or vice versa, how the internal report constrains the internal action of the superior. If the constraint is high, the degree of freedom is low. E.g. if slack in goods and capacity is high the degree of freedom will be high. If the variable pertaining to T, T_1, is loosely defined as a range ($t_a < T_1 < t_b$) in the order, the degree of freedom is also high. If the internal control process of the subordinate is constrained by factors other than the internal order, e.g. expensive set up times, and the superior accepts this without letting it influence his own actions, the degree of freedom is also high. If however the superior takes notice of this and acts accordingly, the degree of freedom is low.

The variety in actions

The variety in the actions available to the internal control problems of superior and subordinate, *Var(M_i)*, is another important process characteristic. The law of possible variety discussed how the availability of more actions may lead to more variety in Ψ. Having more measures or actions available, generally implies that the GAS and the environment of the VAP can be managed better. As was illustrated in the ferry example with flexible departure times, a higher Var(M_i) generally requires more coordination.

Directions for search

The first process characteristic, the data dependency, supports the search for reducing the BU through improved coordination. The relationship between the latter two process characteristics and the usefulness for coordination is depicted in Figure 4.25. In this figure two other search directions are depicted (by the arrows). These are explained next.

If a process has a low DoF, this means that incoming orders largely dictate the subordinate's internal actions (superior constrains subordinate), or that the subordinate's internal action determines the internal report's variables pertaining to T, PO, and X, which subsequently dictates the superior's action (the subordinate constrains the superior). An example of a process with a low DoF is a transport process, where the transporter must pick up and deliver goods at fixed times (and places, of course). Furthermore the trucker does not have much leeway in scheduling his routes, because he has no means of outsourcing and a limited capacity. Coordination with the shippers is not very useful since alterations to truck schedules are not possible as they are not acceptable to the shippers. Orders that cannot be fulfilled are not accepted. The customer service in terms of service availability will hence be at a predetermined (low) level. If the trucker, on the other hand, can hire extra capacity (trucks) from a colleague, i.e. if Var(M_i) is medium, coordination will be useful: knowledge about a forthcoming shipper's order facilitates sourcing of extra capacity. This will result in a higher service availability. If the trucker has a high Var(M), i.e. the trucker can source any amount of capacity almost instantaneously, coordination will not be useful since the trucker can cope with any customer order.

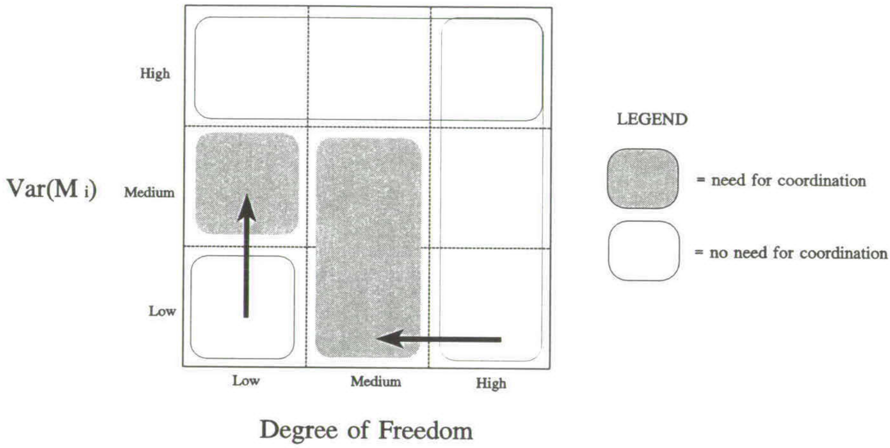

Figure 4.25 - Directions for redesign in the DoF-Var(M_i) grid

In this example we have illustrated the left hand, low DoF, cells in Figure 4.25. We have also illustrated how an increase in Var(M_i) at low DoF may increase the need for coordination. That in the right hand cells, the case of high DoF, coordination is not of much use is obvious, and was already argued at the outset of this chapter.

As EDI is a means of communication which supports, enables, and enhances tighter coordination, we may deduce from this figure two opportunity search areas for redesign induced by EDI. These are depicted in Figure 4.25 by the arrows. Both point in the direction for more coordination. The first is to reduce the degree of freedom in an OU with a high degree of freedom, by reducing slack or by allowing for tighter specifications of variables pertaining to T, PO and X. The second is to increase the variety of M_i in an

OU with low degree of freedom. These extra actions may increase the cost of delivering, but will improve the delivery reliability (recall from the previous section the implications of task uncertainty). This increase of $Var(M_i)$ can be applied to either the subordinate or the superior. Of course both measures, a reduction of the DoF and an increase in $Var(M_i)$, must result in an improved overall business performance which is worth the investment.

4.5.6 Recapping: directions for EDI induced redesign

The research question of chapter one *"1.5 How may the effect of EDI on coordination enable new designs?"* demarcated our approach to redesign in VAPs: in this section we are searching for *EDI induced* redesign. New innovative production machines or highly visionary management philosophies also induce redesign, but these are not discussed here. This is a matter of demarcation. Given this demarcation we set out to develop a theory of coordination, and concluded the following: *coordination reduces uncertainty through its decision making and communicating aspect; EDI as a means of information exchange hence supports intense coordination; we must therefor search for redesigns that require more coordination between OUs.* The redesign directions based on this line of reasoning are only partly related to EDI for the following two reasons.

(a) (Re)designing processes in a VAP so that a higher need for coordination results, requires changes in the way of working, especially in the GAS, that have nothing to do with interorganizational communication, i.e. EDI.

(b) The communication aspect is only one of two aspects of coordination. The decision making aspect requires organizations to design decision rules that will govern their interaction. This, just like the communication aspect, leads to uncertainty reduction. And although there is a bidirectional interaction between the two aspects, the decision making aspect is a design variable in its own right.

So although EDI was the trigger of our problem statement for this section, the solutions have only in part to do with EDI. This is reflected in Table 4.2 which summarizes our discussion: only the first two entries are solely EDI related. The other entries, which are the real redesigns, require more than exchanging information by means of EDI.

The first two entries of Table 4.2, Implementing, and Adapting, have strictly speaking nothing to do with redesign. The third entry has to do with our first strategy for redesign (see section 4.5.2), reducing Boundary Uncertainty (BU). This means sharing more information or sharing the same information more often. Sharing or aligning (new) decision rules and thus further reducing uncertainty about each other's action is not EDI induced. The last two entries, Reducing DoF and Increasing Var(M) are examples of the second strategy, increase the need for coordination and than cope with the communication aspect through EDI.

Table 4.2 - (Re)designing VAPs

Improvement Category	Type	Example	Comment
Implementing EDI	Efficiency	Reducing data entry staff	This is not redesign
Adapting to reduced lead time, improved reliability, and cost reduction	Retuning	Recalculating safety stock	
Reducing BU, through enhancement of the communication and decision making aspect	Break-through	Using echelon stock in a distribution chain	EDI only half of the design. Sharing decision rules (agreements) as important
Reducing the degree of freedom (DoF)	Break-through	Lowering inventory buffers Relying on prompt specified supply times	The realization of such (re)designs is not only contingent on EDI
Increasing the variety in actions Var(M_i)	Break-through	Reducing production batch sizes	The realization of such (re)designs is not only contingent on EDI

4.6 Concluding remarks

In this chapter we have given answers to the following questions posed in chapter one:

1.1 What is coordination?
1.2 Why is it necessary?
1.3 How can it be accomplished?
1.4 What are the factors influencing it?
1.5 How may EDI the effect of EDI coordination enable new designs?

We have called the task of answering these questions our theoretical problem. The rationale for stating this problem was supporting business redesigners in VAPs, in particular with respect to the innovative application of EDI's enabling capabilities. We thus view our theory as an instrument, rather than a body of knowledge of which the truth has to be proven. It provides a way of looking at reality that allows for inferences about the redesign of information exchange between organizations, both in the design and the operational phase. Thus instead of trying to falsify our theory (Popper 1961), its usefulness as a design instrument needs to a be assessed. In the preceding paragraph we have derived from our theoretical concepts directions to guide the redesigner, which is indeed a practical application of the theory.

"A picture according to a Chinese proverb, is said to be worth ten thousand words. A demonstration may be worth ten million" (from Williamson 1975, p.255). We will in chapter five and seven demonstrate our theory's applicability in supporting design.

Chapter Five

Redesign experiments

> *"As far as experimentally derived systems knowledge is concerned, it is obtained by performing and analyzing experiments with systems simulated on a computer or, possibly, in some other way. The computer plays undoubtedly the most important role in this respect and it is perfectly proper to view it as the systems science laboratory."*
> **- G. Klir, 1985**

To illustrate the foregoing concepts and directions for EDI induced redesign (Table 4.2), we will discuss in this chapter some simplified cases of dyads. The first and more elaborate case entails the two echelon inventory problem of a Supplier and a Producer. In this case the first three entries of Table 4.2 are illustrated with the aid of computer simulation. Two other examples illustrate redesigns of the 'increase Var(M) type' and 'reduce DoF', i.e. the latter two entries of Table 4.2.

5.1 Introduction

The strategies for finding EDI induced redesign opportunities (see section 4.5) are based on the preceding theoretical expose on coordination in which the notion of uncertainty is central. A distinction was made between retuning and (breakthrough) redesigns, a distinction without a sharp dividing line. The calculation of a new safety stock level as a consequence of EDI induced uncertainty reduction is an example of retuning. The shift of decoupling point (DP) enabled by shorter lead times as a consequence of EDI is a redesign. The purpose of this chapter is to illustrate the theory presented in chapter four by means of hypothetical cases. In addition to the qualitative discussion, simulation is used to give some quantitative support to the statements made in the first case (section 5.3). The other two smaller cases offer a qualitative discussion of the redesigns presented therein (section 5.4). A purpose of a secondary, but not less useful, nature is to improve the theory's comprehensibility and hence practical applicability through application.

The main objective is to show *how* through reasoning from the theory of chapter four, i.e. improved redesign alternatives can be found. Before presenting the cases and their redesigns, we will describe in section 5.2 the simulation environment in which the redesign experiments of the first case are conducted. The language for specifying designs and the rationale behind the modeling approach contained within that language are discussed.

5.2 Modeling and simulating logistical processes

5.2.1 The rationale behind our modeling approach

Recall from our discussion in section 3.1 of Bosman's (1986) matrix that the class (4) or descriptive-empirical models used in design must ideally be preceded by class (2) or descriptive-conceptual models. The *rationale* ('theory' is too strong a notion) behind our modeling approach is that when designing in business, one must focus on processes (or workflows) and not on departments, functions or actors.[1] From recent literature one may deduce that apparently the adoption of this perspective is not as obvious as it seems. According to Davenport (1993, p.5)

> "Adopting a process view of the business - a key aspect of process innovation - represents a *revolutionary* change in perspective: it amounts to turning the organization on its head, or at least on its side" (our italics).

That people in organizations are not used to think in process terms is emphasized by Hammer (1993, p.117/8):

> "Processes, not organizations, are the objects of reengineering. [...] Processes in a company correspond to natural business activities, but are often fragmented and obscured by the organizational structures. Processes are invisible and unnamed because people think about the individual departments, not about the processes with which all of them are involved. Processes also tend to be unmanaged that people are put in charge of the departments or work units, but no one is given responsibility for getting the whole job - the process - done."

Goods (but also information objects) spend most of their time waiting to be processed. The relative amount of time of actual value creation is very small, some even estimate that this is only 5 % (Johnston & Lawrence 1988). This is to a large extent caused by the optimization of departments and functions, without regard for the integral flow of goods

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[1] The class (2) theory of the preceding chapter is *not* the precursor of the modeling approach outlined in this section.

(or information objects). Taking a process perspective, cutting across functional or organizational boundaries emphasizes the overall work flow and reduces lead time. This is important because as discussed in chapter four time delay nurtures uncertainty, and because in a turbulent business environment business speed is crucial.

In our view basically no distinction should be made between work (tasks) performed by people, machines, or information systems: a process is a concatenation of tasks regardless of who or what performs them.

The modeling approach must meet the following requirements:
- dynamics, i.e. the variable time, must be captured;
- concurrent (and sequential) work flows must be possible;
- information- and goods flows must be integrated in a single model;
- the resulting model must capture processes and not structures, i.e. boundaries between departments and organizations should not appear explicitly in the model;
- it must allow for model evaluations in terms of logistical performance measures.

After Geoffrion (1989) an environment for simulation (of business processes) must consist of :
- a framework for conceptual modelling;
- an executable modeling language that supports this framework; and
- software integration approaches to deal with 'external' software components.

The framework for conceptual modeling, our process approach, is elaborated in the next subsection, while the language and the technical aspects of our simulation tool are briefly touched upon in subsection 5.2.3.

5.2.2 Modeling logistical processes

"Simulation is the process of designing a model of a real system and conducting experiments with this model for the purpose of understanding the behaviour of the system or of evaluating various strategies (...) for the operation of the system" (Shannon 1975, p.2). Using simulation for the evaluation of various strategies for the operation of a system is very useful when designing real systems. In doing so, the simulation tool we developed can very well function as a true 'reengineering support tool'. In this chapter simulation is used as a research instrument, to assess the predictions about the potential of EDI for redesign.

In chapter three we adopted the systems approach and discerned two aspect systems of importance to our study: the information aspect system (IAS) and the goods aspect system (GAS). In chapter four the aspect systems were fleshed out by distinguishing several layers. The coordination-, data administration-, and internal control layer in the IAS, and the physical task-, and physical infrastructure layer in the GAS. The resulting LOM gives a static view of an OU. The modeling approach below supplements this with the dynamics.

A *process* is characterized by a starting point and an end point in time, in between of which some transformation is performed.[2] This transformation requires capacity and may involve information as well as physical objects. A modeling approach which meets the requirements stated in the previous subsection, and adheres to the definition of process just given follows.

The main notion of our approach is that a process consists of *tasks* and the precedence relations between those tasks. The first task in a process is preceded (or triggered) by an *event*. Events may be external, e.g. the arrival of a customer order, or internal, e.g. the attainment of a certain level of goods inventory.

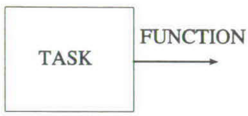

Figure 5.1 - Function and Task (In 't Veld 1988, p.23)

A task is a basic, coherent, amount of work that is performed in the course of the transformation. It may contain several *actions* and *decisions* (using decision rules) and is performed in its entirety or not at all. Apart from this last restriction, the modeler is free in grouping work to tasks: 'a task is in the eye of the beholder'. A task in the IAS is referred to as an *information task* and a task in the GAS is referred to a *physical task*. Be aware not to confuse a 'task' with a 'function' (see Figure 5.1). The latter denotes the contribution of the carrier (or subsystem) of that function to the whole, while a task denotes the work that must be done to fulfil a function.

Tasks may require *performer units* (Oien 1969), and/or *resources*. Both are means to model capacity, the difference being that performer units are task specific, while resources can be available to more than one type of task. The resources and performer units determine the maximum number of instances of a task that may be active simultaneously. Our modeling approach hence allows for two types of concurrency: several instances of the same task and parallel paths of different tasks.

Precedence between tasks is established through *triggering*. When a task is completed it sends a trigger to its successor(s). A task only starts after it has been *enabled*, i.e. the boolean function of input triggers is true, and the required resources and/or performer units are available. Triggers are either messages, steering- or status signals, or dummy triggers. The latter is an empty trigger that establishes hard incidence between tasks. Three special triggering mechanisms have been modeled. *Rate based triggering* is used to model tasks that must be performed periodically, e.g. every hour. With *volume based*

[2] Davenport (1993, p.5) defines a process as " ... a specific ordering of work activities across time and place, with a beginning, an end, and clearly identified inputs and outputs: a structure for action."

triggering a task is enabled after a certain volume of triggers has been received. *Time based triggering* is used to start tasks at predetermined specific points in time. Any boolean combination of these triggering mechanisms is possible.

Tasks may *read* and *write* to the data administration layer which contains *databases*. These may be shared by tasks. Physical tasks may *pick-up* goods from and *drop-off* goods to the physical infrastructure. The *physical infrastructure* models the physical locations, the storage capacity of those locations, and the paths between locations.

The LOM and the modeling approach come together as indicated in the figure below.

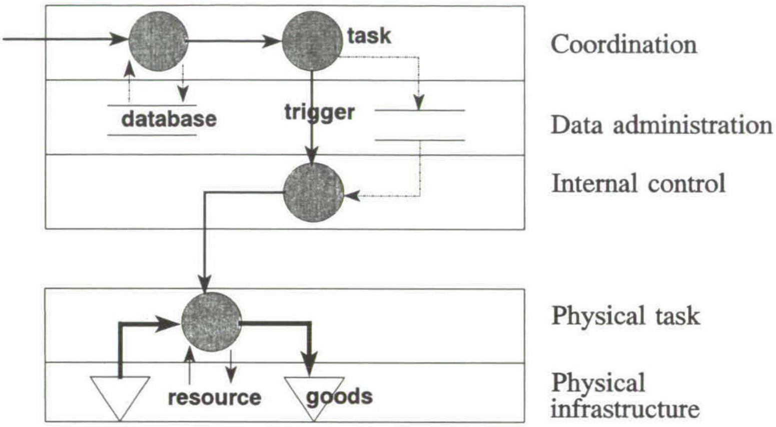

Figure 5.2 - The Layered Organizational Model and the graphical modelling language

Remark. Within an organization or dyad several processes may exist. These process touch upon each other in *process decoupling or interaction points* (e.g. shared databases or shared inventory), which should not be confused with the customer order decoupling point. An illustration of different processes and their process interaction points is given in the case studies of chapter seven. In Annex 7.II the modeling approach is also applied to real life process.

5.2.3 An environment for simulating processes

The building blocks of the modeling approach have been implemented in SIMULA/DEMOS (Birtwistle 1985). An easy to use language, called PSL (process specification language) that has a one-to-one correspondence to the building block specified in the previous section was developed. Models specified in PSL are parsed to SIMULA code for execution.

A simulation language serves the following purposes (Dahl 1968). It:

(1) provides the analyst with a conceptual framework
(2) gives a notation for the description of a model
(3) serves as a programming aid; simulation languages as compared to high level languages are easy to program, and result in easy modification of models in case of experimentation.

An illustration of our modeling language PSL is given in annex 5.II. An elaborate description of the simulation tool and the syntax of the modeling language PSL can be found in Chin A Lien (1993).

5.3. A supplier - producer VAP

In this example we will illustrate the predictions of our theory, i.e. the first four entries of Table 4.2 on redesign induced opportunities. These are in the order presented in this section: (1) merely implementing EDI, (2) retuning to the EDI attributes, (3) reducing the boundary uncertainty (BU). The fourth and fifth entry, reducing DoF and increasing $Var(M_i)$, are discussed by means of some additional illustrations in section 5.4. In section 5.3.1 we will give a description of the VAP, in section 5.3.2 EDI is introduced and (1) and (2) are illustrated, and finally in section 5.3.3 we illustrate the redesign (3). The purpose is to demonstrate, apart from its predictions, the power of our coordination theory as a vehicle for reasoning about redesigning logistics in VAPs.

5.3.1 Description

Consider the dyad consisting of two production OUs, one called the Supplier, supplying parts to the other called the Producer (see Figure 5.3). The Supplier is the only supplier to the Producer, and the Producer is the Supplier's only customer. Both OUs deliver from stock, and the Producer uses a (s, Q) strategy for inventory replenishment, i.e. the inventory is reviewed continuously, and as soon as it drops below level s_P, a quantity of Q_P units is ordered. The Supplier sources from an OU which is called the External supplier, and uses a (t, Q) strategy, i.e. an amount of time, t_S, after a certain event occurs, e.g. the inventory drops to zero, a replenishment order of size Q_S is placed with the External Supplier. The Producer has a 'no stock, no sale' policy, i.e. customer orders are not taken into backorder. The Supplier in contrast uses a backordering policy for the Producer's orders. An analysis of the inventory models is given in Annex 5.I. The notation used is given in Exhibit 5.1.

Lead times

Prior to the introduction of EDI the internal order (from Producer to Supplier) is exchanged by postal mail. As a consequence of the manual processing of orders, the lead time in the IAS shows some variability, due to e.g. varying loads of data entry personnel,

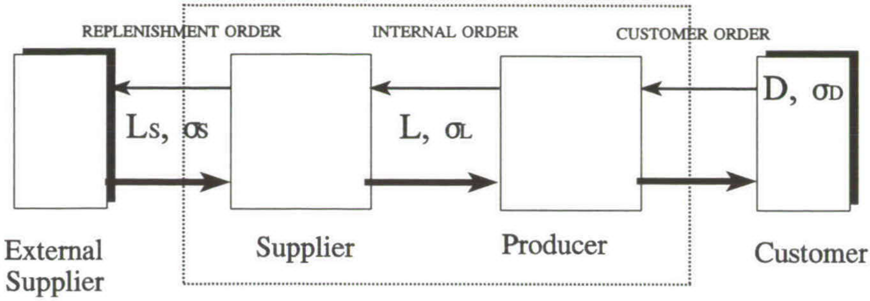

Figure 5.3 - The Supplier Producer VAP

errors and their correction. Adding the average duration of the physical delivery and its variability, the total internal lead time, L, has some variance σ_L. For the same reasons the external supply lead time, L_S is also stochastic. The internal lead time is drawn from a normal distribution with mean L_S of 280 time units and a standard deviation σ_L of 100. The internal lead time includes the time of order entry and processing. The external lead time, the lead time to the Supplier, is also drawn from a normal distribution with mean L_S of 200 time units and standard deviation σ_S of 80. Thus

$$L \sim N(280, 100)$$
$$L_S \sim N(200, 80).$$

D = average demand per time unit, in units/time unit
σ_D = standard deviation of demand, in units
L = average internal lead time (from stock), in time units
σ_L = standard deviation of lead time
L_S = average external lead time to the Supplier, in time units
σ_S = standard deviation of the external lead time

Q_P = pre-specified order quantity of the Producer, in units
s_P = order point for the Producer, in units
Q_S = pre-specified order quantity of the Supplier, in units
t_S = order point for the Supplier, in time units

k_P = safety factor (using P_2) for the Producer
k_S = safety factor for the Supplier
P_2 = specified fraction satisfied directly from the shelf by the Producer
P_1 = the probability of stock-out at the Supplier during his own replenishment cycle

Exhibit 5.1 - Notation used in the description of the VAP

Demand

The demand process is simulated by an order arrival pattern with a negative exponentially distributed inter arrival time (IAT), and of unit size. The resulting demand function has a Poisson distribution. We have chosen an IAT of 5 time units which sets the mean and standard deviation of the Poisson distribution at

$$D = 0.2 \text{ unit/ time unit}$$
$$\sigma_D = \sqrt{0.2} \;\; (\sigma_D^2 = 0.2).$$

Coordination in the large

During the design phase of their partnership both OUs have agreed to achieve some *coordination in the large*, by adjusting their batch sizes. First of all, the parties have agreed that the Producer always orders batches of a fixed size. Secondly, the fixed batchsize, Q_P, is known and the ordering batchsize of the Supplier, Q_S, is a multiple of Q_P ($Q_S = n^*Q_P$). It is easy to understand that such an adjustment in the design phase reduces unnecessary inventory on the part of the Supplier. Both batchsizes are determined on the basis of the OUs their ordering and inventory carrying costs. (See annex 5.I for the underlying principles of this determination.) Table 5.1 contains the dimensions of the process. Notice that because of the coordination in the large the Supplier bases his ordering policy on actual customer demand, and infamous distorting effect called *demand uncertainty amplification* which is inherent to supply chains is not present, even in the situation without EDI.

Table 5.1 - Process dimensions

Given	Chosen
$D = 0.2$ unit/time unit $\sigma_D = \sqrt{0.2}$ $(\sigma_D^2 = 0.2)$ $L \sim$ Normal (280, 100) $L_S \sim$ Normal (200, 80)	$Q_P = 80$ units $Q_S = 160$ units $(n=2)$ $s_P = 63$ units $t_S = 170$ time units

Performance measures of the process

The three measures for evaluating the performs of logistics design, lead time, delivery reliability, and cost (see chapter three) are discussed in terms of their applicability to this case.

Lead time. The lead time to the customer after the DP (i.e. the Producer's inventory) has a deterministic value. Delivery from the shelf does not depend on capacities, as sufficient delivery capacity is assumed. Therefore all orders delivered from the shelf have the same lead time. This performance measure is not useful to evaluate this VAP's performance.

Delivery reliability. The reliability of the VAP is measured in terms of the percentage of stock-outs. The higher the percentage, the lower the delivery reliability of the VAP.

Cost. In this simulation study we will use a simplified version of the coordination cost as defined in chapter three. The only costs considered are inventory carrying costs. The costs of ordering and transportation only emerge in the discussion of one of the experiments. An additional simplification is that we will use the sum of the average inventory levels at the Supplier and the Producer as a representation of the inventory carrying costs.

Given the settings of Table 5.1 the performance of the VAP with postal exchange, henceforth referred to as the Base Model, is as given in Table 5.2.

Table 5.2 - Performance without EDI

	"Base Model"
Stock-out	6.9 %
Inventory Producer	48 units
Inventory Supplier	49 units

Uncertainty analysis

The **intrinsic uncertainty** (IU) consists of the demand uncertainty which is reflected in the standard deviation of the demand pattern, and the supply uncertainty which is reflected in the standard deviation of the supply lead time.

Both the Supplier and the Producer their **task uncertainty** is related to the uncertainty during their supply lead time, i.e. the variation of the demand over the lead time. Through their internal design, which is in this simple case the selection of the safety stock (the Producer) or safety lead time (the Supplier), the OUs are left with a certain amount of task uncertainty. The higher the average levels of inventory in their DPs, the lower the task uncertainty of the OUs.

The **GAS uncertainty** is reflected in the standard deviation of the internal supply time. (The uncertainty in the external supply time is part of the IU.) The larger the standard deviation, the larger the GAS uncertainty.

The **boundary uncertainty** (BU) works two ways: uncertainty for the Supplier because he has no sight on the arrival of customer orders. The Supplier cannot observe changes in customer demand, and only gets information about customer behavior after Q_P customer orders have arrived. The boundary uncertainty for the Producer is more difficult to illustrate because of the simplification of the Supplier's process: just one task with one lead time to deliver the internal order. If the lead time is comprised of different segments, each with its own standard deviation, the Supplier has knowledge about the progression of the internal order and hence knows with more certainty what the actual lead time for a particular order will be. This lack of insight for the Producer constitutes his boundary uncertainty.

5.3.2 Implementing EDI

EDI is only used between the Supplier and the Producer, i.e. internal to the VAP. EDI, through its attributes reliability and speed (see section 4.5), reduces the average and standard deviation of the internal lead time, which means that the reorder point s_P can be reduced (a reduction of the lead time stock as well as the safety stock). This change caused by EDI is a status-quo redesign, or more appropriate, a retuning of the existing processes.

Introducing EDI is modeled as follows:

(1) a reduction of the internal lead time, L;

(2) a reduction of the standard deviation of the internal lead time, σ_L and as a logical consequence of equations (3) and (4) in Annex 5.I;

(3) a reduction of the reorder point s_P at the Producer (retuning).

Retuning (1)

In the first alteration we will thus introduce EDI for the exchange of the internal order, by reducing the internal lead time L and its standard deviation, σ_L due to reduced order processing time and its standard deviation:

$$L := 140$$
$$\sigma_L := 30, \text{ i.e. } L \sim N\,(140,\ 30)$$

Without any further alterations to the design, i.e. just implementing EDI without changing the parameters of the blueprint as stated in Table 5.1, we observe the VAP performs as specified in the first column of Table 5.3. The data in the first column is not realistic, since the Producer who is now facing a shorter internal lead time, with less variance (i.e. less uncertainty) will lower his reorder point to

$$s_P := 28 + k_P.8, \text{ and with } k_P = 0.3,\ \ s_P := 31.$$

The performance after retuning the Producer's inventory policy are given in the second column of Table 5.3.

Table 5.3 - Performance after Implementing EDI and Retuning for EDI

	"Merely implementing EDI" $s_P = 63$ ($t_S = 170$)	"Retuned for EDI" $s_P = 31$ ($t_S = 170$)
Stock-out	0.2 %	4.1 %
Inventory Producer	71 units	42 units
Inventory Supplier	45 units	48 units

Discussion
Merely introducing EDI without retuning the control policies may result in undesirable behavior as shown in the table above. The delivery reliability may be high, but this is better than customers are willing to accept, at the expense of high inventory at the Producer.

The retuned design, although EDI results in a reduction of the internal lead time by 50%, does not dramatically outperform the original design without EDI, the "Base Model". With an average of 7 units (approximately 7.2 %) of inventory less, the stock-outs are reduced by 2 % after introducing EDI and retuning the design. The improved performance can be attributed to the reduced task uncertainty for the Producer, in demand, as well as in supply. The Producer can reduce the safety stock because the period [t, t+L] over which he needs to make the prediction is reduced (L from 280 time units to 140 time units), and hence the spread in demand over that period is reduced, and with it the demand uncertainty for the Producer. Also his supply uncertainty is reduced because of the reduced variance in the internal lead time.

Retuning (2)

EDI has the capability of increasing the ordering (in general message) frequency. In the following retuning the batch size Q_P is reduced by 50% because of the lower costs of ordering (see eq.(1) in annex 5.I).

Table 5.4 - Performance after retuning (2)

	Q_P = 40; with EDI
Stock-out (%)	4.5 %
Inventory Producer	25 units
Inventory Supplier	34 units

Discussion
Comparing this performance with that of the previous retuning for EDI learns that through the redesign approximately the same customer service can be obtained with 40 % less inventory. In our limitation of cost to inventory costs, we ignore the fact that the number of internal deliveries has doubled. What the effect is on the transportation cost depends on the characteristics of the operational transportation process. The economical feasibility of this redesign depends on the trade-off between saved inventory costs and increased transportation cost. A lesson learnt here is that retuning for EDI may yield significant benefits, even before any redesign was performed.

5.3.3 Reducing BU

EDI enables the sharing of variables, in this case the inventory level of the Producer. This opens up the redesign opportunity of having an entirely different control policy. This sharing of data in itself does not constitute a reduction of the *internal demand uncertainty* of the Supplier, because his internal control policy does not make use of this variable. However, the sharing enables a different internal control policy at the Supplier (redesign), which uses the variable and which does effectuate less boundary uncertainty than the 'old' internal control policy. We have added to this example that customer orders are taken in backorder.

The uncertainty reducing effect of EDI is intuitively easiest to understand for the variable sharing capability of EDI: the *more* and *more often* one gets information, the lesser one's uncertainty. Still, in business, information only leads to uncertainty reduction if the internal control task of the receiver can benefit from it, one way or the other. In this experiment we will show how the shared variable is capitalized on by changing the internal control policy. This is example of facilitating the data dependency labelled (2) in our data dependency diamond (chapter four): $\mathbf{G}_{\text{subordinate}} \leftarrow \mathbf{S}_{\text{superior}}$.

The Supplier gets access to the superior's inventory level (shared variable), which reduces his task uncertainty (TU) and either improves the internal delivery reliability or reduces his (raw materials) stock level. In order to sustain the uncertainty reduction the Supplier needs to change his control policy from a safety lead time (reorder point as in eq.(4) of annex 5.I) to a safety stock. If the *echelon inventory* drops under s_S, an order to the External supplier is placed. Echelon inventory is the total inventory in the VAP which has not yet been sold. Thus the Supplier can only calculate the echelon inventory if he has access to the Producer's inventory. For this new order point s_S of the Supplier we use the formula derived from De Bodt & Graves (1983) (in Silver & Peterson 1985, p.478):

$$s_S = D.(L+L_S) + k_S.\sqrt{((L+L_S).\sigma_D^2 + D^2.(\sigma_L^2 + \sigma_S^2))}$$

This control policy will reduce (time) slack (and hence carrying costs) for the Supplier, since his 'estimation' of when the internal order will arrive has been improved. See here the task uncertainty reduction enabled by EDI.

Table 5.5 - Performance of the Shared Variable design and the (t,Q) design, both with backordering

	(t,Q) Model $s_P = 31$; $t_S = 170$	Shared Variable $s_P = 31$; $s_S = 74$
Late deliveries	6 %	6 %
Inventory Producer	40.7 units	40.6 units
Inventory Supplier	45.9 units	44.7 units

Discussion

Comparing this with the retuned EDI model (first column of Table 5.5) shows that the performance remains unchanged, and one may wonder why the communication intensive shared variable design was implemented. That the performance hardly improves is not surprising since there is hardly any boundary uncertainty in the example as we have presented it sofar. The Supplier, knows just as the Producer that the customer demand has an average of 0.2 units/time unit, and a standard deviation of $\sqrt{0.2}$. They have exchanged this information in the design phase of the VAP. If however customers do not behave this predictable, boundary uncertainty rises: while the Producer knows that customer demand is deviating, the Supplier does not know this until the internal order arrives earlier or later than expected. Based on our theory, we expect that the shared variable version will outperform the EDI version based on a (t,Q) ordering policy for the Producer, because of its BU reduction potential. The following simulation results in which demand is varied confirm our expectations.

Table 5.6 - Comparison of efficacy of the shared variable and (t,Q) model

Varying Demand		Invent. Producer	Invent. Supplier	Late de-liveries
D ~ 0.29	SV	25.9	33.7	25.3 %
IAT = 3.5	(t,Q)	23.1	26.6	32 %
D ~ 0.25	(SV)	31.3	38.2	16.4 %
IAT = 4	(t,Q)	29.3	34.1	20 %
D ~ 0.2	SV	40.6	44.7	6 %
IAT = 5	(t,Q)	40.7	45.9	6 %
D~ 0.1667	SV	47.3	50.3	1.9 %
IAT = 6	(t,Q)	47.9	56.5	1.6 %
D ~ 0.1428	SV	51.5	56.4	0.2 %
IAT = 7	(t,Q)	51.7	67.1	0.2 %

As can be observed the shared variable model has a better delivery reliability than the (t,Q) model in the case of under estimation of demand (IAT = 4 or 3.5), while in case of over estimation (IAT = 6 or 7 instead of 5) the shared variable model is able to keep the inventory down. Figure 5.4, which is a graphical representation of Table 5.6, shows that the shared variable model is more sensitive to changes in customer demand. This sensitivity is a measure of *efficacy* (see chapter three). We may hence conclude that the models compared in the figure are equally effective (delivery reliability), that the shared variable model is slightly more efficient (inventory cost), and outperforms the (t,Q) model efficacy wise (sensitivity to non stationary demand).

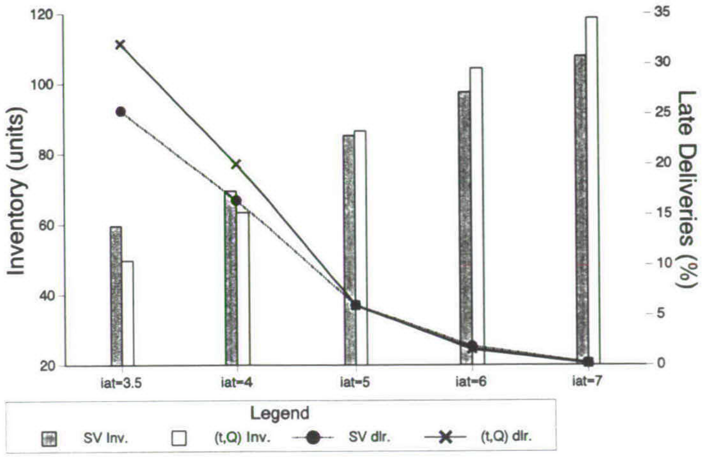

Figure 5.4 - Larger efficacy for the shared variable design

The shared variable model at first sight seems not to be worth the effort. It is only after further investigation that the benefits of the shared variable design, its superiority in terms of efficacy, are revealed. A similar observation is made by Polman & Kok (1991) with respect to the implementation of another type of ITT, i.e. Computer Integrated Manufacturing (CIM). They argue that because the flexibility benefits of CIM, which they regard as the prime ratio for adopting CIM, are less obvious, it is difficult to defend the investments needed to fully implement CIM. A possible pitfall the EDI redesigner should also be cautious of.

5.4 Reducing DoF and increasing Var(M)

In this section the fourth and fifth entry of our Redesign Table, 'Reduce Dof' and 'Increase Var (M)', are discussed. The rationale behind the latter redesign opportunity finding guideline is Ashby's (1958) law that only variety can destroy variety, or our derivation of it, called the law of possible variety: only variety can create variety. Because EDI enables us to get more information from the environment we can design improved actions, M, to control that environment. More than is the case with the other guidelines, EDI is a necessary, but by far not sufficient requirement for redesigns based on this guideline. We will give two illustrations.

5.4.1 Reducing the DoF

Consider a Producer and his Distributor (Figure 5.5). The Producer has a number of different articles, say three, and keeps finished good inventories (FGI) for all these articles. The decoupling point (DP)[3] is located at the Distributor, and hence the majority of FGI is located at the Distributor's warehouses due to lead time requirements by customers. The Producer must keep safety stocks at the Distributor's warehouse for all three articles. Customer orders received by the Producer are relayed to the Distributor who delivers the goods.

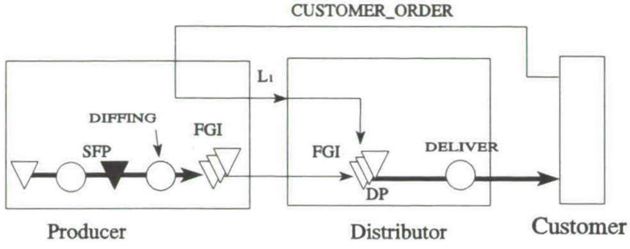

Figure 5.5 - Before the implementation of EDI

Now suppose that the articles are differentiated versions of some semi finished product (SFP), and that this differentiation is accomplished through a task called DIFFING. If the Producer lets the Distributor perform this task, the Producer needs to keep inventory for only one item, the semi finished product (see Figure 5.6). As before customer orders are relayed to the Distributor, who performs the task DIFFING to order.

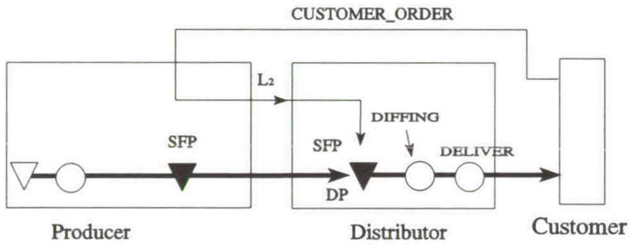

Figure 5.6 - With EDI induced redesign

How has the DoF decreased in this redesign? And why is more EDI enabled coordination required? The DoF is reduced because the process of the Distributor has become more dependent on the order acceptance by the Producer. Vice versa the Producer has to be more considerate of the capacity of the Distributor, i.e. in addition to DELIVER-capacity now also the DIFFING-capacity has to be considered, when accepting orders. The variety in actions of the Distributor has increased: instead of merely delivering he has the ability to control (and perform) the task DIFFING. As the variety in tasks of the Producer has decreased, the overall task variety in the VAP was not changed.

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[3] The decoupling point (DP) separates the on customer order driven processes from the forecast driven processes (see chapter three).

The communication and coordination between the Producer and the Distributor in our description sofar have not changed: the INTERNAL-ORDER contains all the information needed by the Distributor to differentiate and deliver. However, because of the extra task, the Distributor's internal control problem has been elaborated: he must predict the capacity needed to perform the task DIFFING. This is where the need for more coordination arises. The Producer must communicate anticipated changes in customer demand to the Distributor. Furthermore, for instance, the timing of promotional actions must be adjusted with the Distributor to make sure these fall in a period in which the Distributor has extra capacity available to perform the task DIFFING. This can e.g. be accomplished by giving the Producer access to the Distributor's orders database in order to ascertain the latter's load (the Distributor has more than one customer). EDI supports the communication aspects of this extra coordination.

Apart from supporting the more intensive communication required, EDI enables this redesign also because of the reduced lead time in the IAS: $L_2 < L_1$ because of EDI's speed attribute (see Figures 5.5 and 5.6). This reduction of the internal order lead time (among other things) allows for shifting the physical task DIFFING, with its duration, from before the DP to after the DP. (The delivery time to the customer must remain unchanged.)

In this illustration the internal design was changed by moving the DP upstream, while at the same time redeploying a physical task. By changing the internal design, the task uncertainty has been greatly reduced for the Producer, because instead of predicting for three items well in advance, he needs only to predict for the semi finished product. The task uncertainty (TU) for the Distributor has increased because he needs to predict the required capacity to perform the task DIFFING. However, this increase is less than the decrease for the Producer since the Distributor only needs to make predictions about the total number of orders to determine his capacity, whereas the Producer needed to make predictions for each of the three products separately. Making separate predictions is more difficult, and hence the task uncertainty at the VAP level before the redesign was higher.[4]

Because of the overall reduction of the TU for the VAP, assuming the same amount of coordination with the environment, the number of deviations from the required performance and/or the extra cost of emergency measures will be lower (see Figure 4.18). Out of stocks, e.g., are less likely to occur in the redesigned situation, because it is easier to predict a single aggregated variable, than it is three particular variables. Notice that because of redeploying the task DIFFING the boundary uncertainty for the Distributor first increases and is subsequently coped with through increased internal coordination.

The economic and technical feasibility of performing DIFFING to customer order are assumed in our description. In the following real life example it was indeed feasible. Davis (1993) reports on a redesign similar to the one described here between a manufacturer of printers and his distributor. The task pushed downstream to the

[4] If for instance there are three products, FG_i $(i=1,2,3)$, and $\sigma(FG_i)$ denotes the standard deviation of demand for FG_i in a certain period, then $[\sigma(FG_1) + \sigma(FG_2) + \sigma(FG_3)] > \sigma(FG_1 + FG_2 + FG_3)$

distributor is the packaging task. This includes adding the manual in a certain language, and adding a power supply for a specific country. By postponing the country specificity adding, inventory savings of 30 %, mounting up to $ 30 million a year are reported.

We have here an example of the Value Added Logistics (VAL) concept, which refers to the postponement of value creating tasks (e.g. assembly, order picking) by a manufacturer (A.T. Kearney/Knight Wendling 1993). These tasks are ideally performed to customer order by logistics service providers (or importers, wholesalers, or agents as Van Goor (1994) points out) that are located closer to the markets. This often means increased flexibility at the expense of higher labor costs. Examination of the trade-offs between production, inventory, and transport (the PIT-model, INRO-TNO 1994) is an essential task in designing VAL arrangements/partnerships. The cost of the more intense coordination between manufacturer, service provider, and the market also plays a role in the trade-off equation. This study provides insight into the shifting task uncertainties inherent to the VAL concept and supports the design of the ensuing need for coordination.

The redesign in terms of our Redesign-Grid is shown below. The DoF is reduced because the independence of decision making between organizational units has been reduced, as e.g. with the promotional actions. At low DoF and medium Var(M) the need for coordination is higher than at medium DoF and medium Var(M).

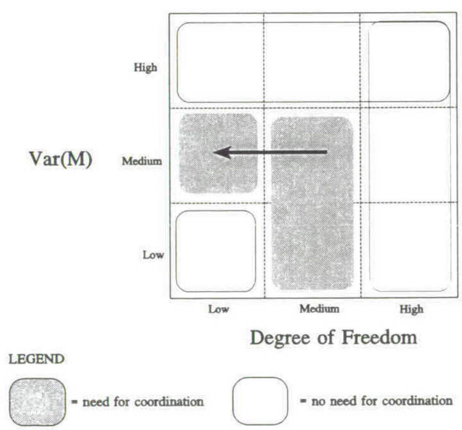

Figure 5.7 - Schematical depiction of redesign (1)

5.4.2 Increasing internal ordering variety

In the following illustration a Producer introduces two phases in ordering from his Supplier instead of one phase. Before the redesign, as depicted in Figure 5.8, the Producer needs to predict his needs for product SUPPLY-B L_1 time units in advance. The Supplier produces to order and because of the sufficient lead time L_1 he has no need to make predictions. No operational coordination is taking place between the Producer and the Supplier, because of the high DoF in terms of the lead time.

Through redesign an extra action is added to the control actions of the Producer (see Figure 5.9). At time t=1 an INTERNAL-ORDER for the subassembly PART-A is placed. The period over which the Producer needs to predict for PART-A is L_1. At t=2 a second order, this time for SUPPLY-B is placed. As the lead time for this second order is only L_2 time units ($L_2 < L_1$) it is easier to predict the amount needed at $t=2+L_2$. This because of the shorter period over which to predict and because the actual customer orders at time t=2 give a better impression what the need for SUPPLY-B will be at time $t=2+L_2$. This ordering in two phases or levels resembles Kreuwel's (1994) multi level supply control (MLSC).

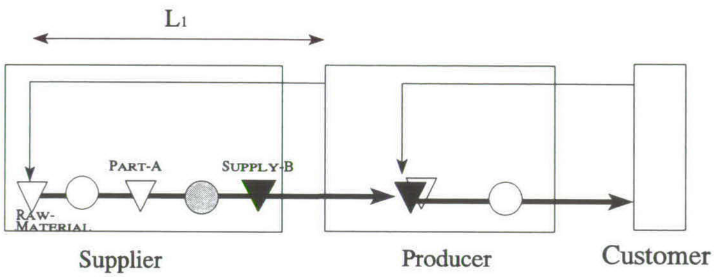

Figure 5.8 - Before Redesign: one INTERNAL-ORDER

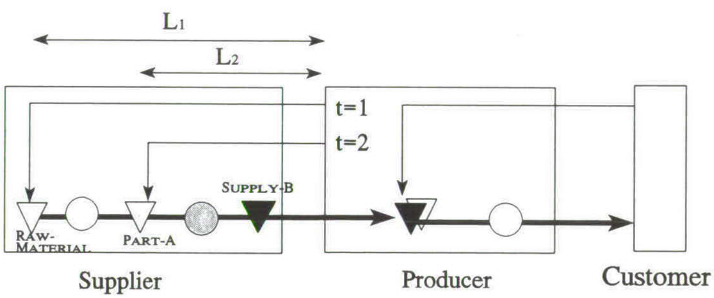

Figure 5.9 - Redesigned: two phase internal ordering

We will next discuss how Var(M) has increased through redesign and how this affects the coordination in the VAP. The fact that the Producer now has two control actions, the first and the second internal order, is obviously an increase in the Var(M) for the Producer. Both parties will have to agree in the design phase on e.g. the allowed time lapse between the first and the second order, and on the percentage of allowed deviation between the two order quantities. Adjusting these extra variables in the design phase is called coordination in the large.

The need for operational coordination arises because the Supplier has less leeway in delivering the second order. By reducing the delivery cycle, the Producer's production process becomes very dependent on the reliability of supply, both in terms of delivery reliability as well as in terms of product quality. The increases the required performance of the Supplier and hence his task uncertainty. The Supplier will therefore benefit from access to the Producer's database containing actual customer orders, which is operational coordination.

The ability to order in two steps, makes the second prediction more accurate. The period over which to predict has become shorter, and hence the variance in demand over that period is lower. This the task uncertainty for the Producer has been reduced. This while the task uncertainty for the Supplier has been increased as was just described. This redesign is supported by EDI because of the more intense form of communication, and the greater need for reliable communication.

Van Overbeek (1992) describes a similar redesign for a truck manufacturer and one of his suppliers. He goes as far as to let the second INTERNAL-ORDER be based on actual customer orders, and not on some forecast over a period L_2 as we have described. The feasibility of such a design is contingent on the production infrastructure of the supplier, his physical distance to the manufacturer, and the transportation cost structure. For an actual implementation of the redesign principle discussed in this subsection, Van Overbeek (p.17) reports drastic improvements, e.g. an inventory reduction from 12 days to half a day, and storage space reduction from 292 m^2 to 47 m^2.

This redesign in terms of our Redesign-Grid are shown below. The DoF is reduced because the action in the different organizational units are linked twice as often as in the case before the redesign.

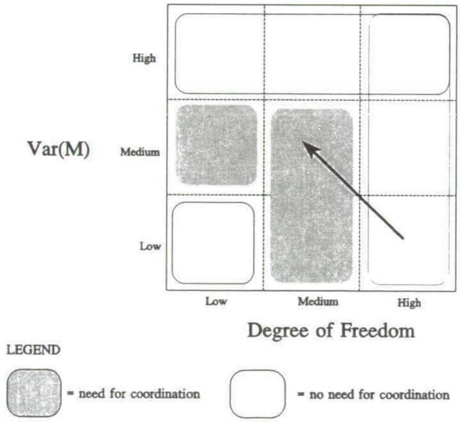

Figure 5.10 - Schematical depiction of redesign (2)

5.4.3 MLSC and coordination

Both cases presented in this section have to do with the manipulation of the decoupling point: either shifting it upstream and down the chain (the first case) or differentiating it (the second case). The latter case resembles Kreuwel's (1994) form of MLSC called "DP downstream differentiation with delayed specification". The other form of MLSC he distinguishes is called "DP upstream differentiation with earlier aggregation". Essential in the multi level supply chain control strategy is that demand is aggregated over time and at the same time over product. For the MLSC concept to work technically there are two conditions:

- the product structure must contain product *families* (and perhaps even product groups);
- the supplier's production process must have a *common trajectory,* i.e. a part in the production process which is shared by products in a product family.

The notion 'design for logistics' is very important in the implementation of MLSC strategy: the process, i.e. the common trajectory, and the product structure must be aligned and suitable for adding variety as late as possible ('mushroom' design, see e.g. Mather 1993).

In the case of MLSC the task uncertainty of the dyad is increased by setting stricter requirements on required performance. The requirements on performance are stricter ($RP_1 > RP_2$ in Figure 5.11) because the supplier has a shorter time to deliver the customer order ($L_2 < L_1$ in Figure 5.9). That this increases his task uncertainty is due to the fact that he has less time leeway in delivering the order and the fact that safety stock for PART-A is more expensive than the raw material stock and hence need to be carefully predicted. The internal design is changed from having one decoupling point (ID_1) to having a differentiated decoupling point (ID_2).

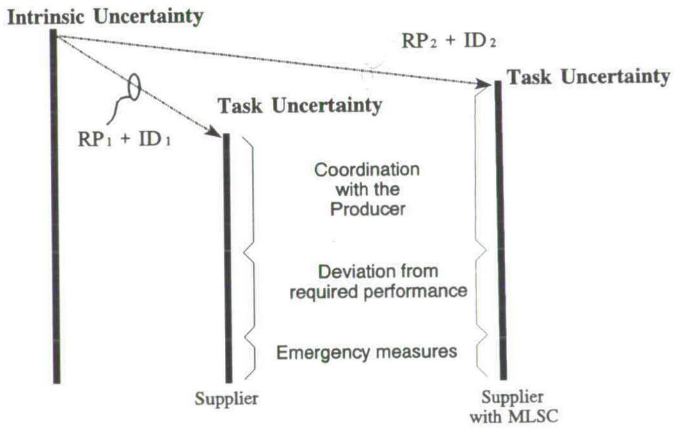

Figure 5.11 - Task uncertainty for the Supplier after introduction of the MLSC strategy

In Figure 5.11 we see an increase in task uncertainty for the supplier which is coped with by more coordination with the producer than before. This coordination manifests itself as the order/message preceding the actual order for SUPPLY-B. The gain of MLSC is that the orders placed by the producer are more accurate and hence the producer is better able to follow customer demand. Furthermore (safety) inventory is reduced at the supplier as a consequence of commonality of products and uncertainty reduction through coordination.

Notice that more coordination is possible in case of MLSC because of the design of the GAS: the common trajectory in the production process and the structure of the products. This emphasizes the point that the quest for the reduction of internally generated uncertainty in a VAP may be impeded by the goods aspect system (GAS). In other words, more information can reduce boundary uncertainty only to a certain point. Vice versa, redesign of the GAS, i.e. changing the internal design, may enable more coordination.

5.5 Concluding

The purpose of this chapter was to apply the design guidelines, i.e. all the entries of the Redesign Table presented at the end of chapter four. The strength of hypothetical cases is that one can focus on the essentials, and manipulate all variables in order to prove a point. A weakness of hypothetical cases is that the reader may have to bridge the gap with reality himself. Although some attempts to relate to reality were made by referencing empirical literature, our aim was to show the workability of the guidelines, i.e. the interaction between our theoretical concepts and the need for coordination. How the concepts are found in reality is described in the cases of chapter seven. First some practical design support knowledge is developed in the next chapter.

Chapter Six

Communicating organizations

"The use of metaphor implies a way of thinking and a way of seeing that pervade how we understand our world generally"
- **Gareth Morgan,** Images of organizations, 1986

Opposed to chapter four which focused on the development of theory, i.e. knowledge *for* design, this chapter presents neither a theory, nor a mere description of organizational communication. Instead it presents a *way of looking* at organizations as communicating systems. The purpose of this chapter is to derive through analogy/metaphor knowledge *on* design i.e. practical guidelines and instruments. Two bodies of knowledge dealing with communication, speech act theory and communication theory, are borrowed from to give substance to the metaphor "organizations as communicating systems".

6.1 Introduction

Communication between organizations takes several forms and is performed for several reasons. Communication between people belonging to different organizations can be formal, e.g. in proposing for a research grant, or informal, e.g. in a sales call. It can be conducted by several means e.g. by phone, mail, EDI, or face to face (e.g. over dinner). Communication is needed for different reasons, e.g. to discuss the potential merger of two organizations, to renew the terms of an existing contract, or to make a request for quotation. Obviously we are not concerned with all these diverse types of communication. Formal communication between organizations at the operational level is of interest here, because this type of communication is eligible for being conducted by means of EDI.

Outline
In chapter four we explained that organizations communicate to coordinate. Here we are not concerned with the reason of communication, but instead try to introduce two ways

of thinking about communication which should guide and improve our ways of designing communication. The first is to think of organizations as communicating *systems* in which several levels of communication may be discerned according to *communications theory* (section 6.2). The second is to think of organizations as communicating actors, which through their exchange of messages perform acts that may change the state of their *conversation* (section 6.3). This perspective of messages or more generally, language, is embodied by *speech act theory*. Both metaphors have resulted in a guideline and a tool respectively, that can be applied when designing inter organizational communication. The content of sections 6.2. and 6.3 is summarized in Table 6.1. In section 6.4. a method is presented that integrates the practical deliverables of this chapter with the theoretical ones of chapter four.

Table 6.1 - The results of using metaphor

Metaphor	*Theory used*	*Tool/Guideline*
Communicating Systems	Communications Theory (Shannon & Weaver)	Comm. partitioning tool Separate Level B and C
Communicating Actors	Speech Act Theory (Searle, Winograd & Flores)	IR state diagram Support all transitions

Before each of these metaphors is explored it is essential to understand the difference between two different models or modes of communication.

Models of communication

There are two models of communication which are depicted in Figure 6.1. The most common of the two is communication through a channel, the other is communication through a shared variable (see Conant 1979). In communication through a channel the source and destination are entities (e.g. computer applications, human beings) which respectively produce and consume the information exchanged via messages. Communication through a shared variable requires some procedure for interpreting the variable shared. It is not necessary that the variable is manipulated by the source or destination, but this is often the case. Though the communication through a channel is the easiest to imagine, Conant (1979) speculates that non-channel communication could be the dominant form of communication in society. We will next give two examples of non-channel communication.

EXAMPLES

(1) Communication through a shared variable is achieved if a producer has agreed upfront on the following procedure with his supplier, "as soon as there are less than two full pallets on the producer's yard deliver 20 pallets". The supplier has a view of the producer's yard. The variable shared is the actual number of pallets on the yard.

(2) Another example of communication through a shared variable occurs when two people have agreed to meet each other on the beach every time the temperature rises above 30 °C. The variable shared here is the temperature.

In the first example the variable shared is manipulated by the producer, while in the second example the variable is not manipulated by either of the communicating parties.

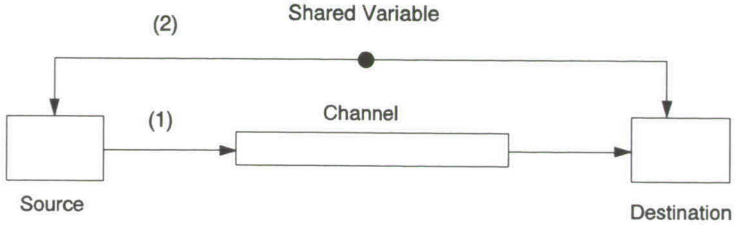

Figure 6.1 - Two models of communication (after Conant 1979)

Both models of communications are apparent within and between organizations. The shared variable model may be implemented through linked or shared databases. Be cautious not to confuse the physical channel that provides access to a shared database or that carries the updates in the case of a linked database, with the conceptual channel of Figure 6.1. A thorough grasp of these two models of communication is essential in the following sections discussing the metaphors.

6.2 Organizations as communicating systems

Organizations communicate by sending messages, messages with an *intended effect*. It is this intended effect which distinguishes communication from mere data exchange. After Weaver three levels of communication problems are discerned (Shannon & Weaver 1949, p.4), and interpreted in case EDI is the means of communication . The resulting stack is called the *communication partitioning tool*. The levels are:

Level A: How accurately can the symbols of communication be transmitted? (*technical*)

Level B: How precisely do the transmitted symbols convey the desired meaning? (*semantic and pragmatic*)

Level C: How effectively does the received meaning affect the conduct (response) in the desired way? (*effectiveness*)

Level A. The technical problems of level A include the technical transmission of symbols, as well as the problem of unravelling the different segments of messages (syntax). Standardization sees to it that the sender and the receiver use the same technical transmission protocols (sub-problem A1), as well as the same message structure (A2 sub-problem).

Level B. Although standardization bodies define the purpose of messages, the exact meaning of messages and the associated response are often determined by the communicating parties (level B). They must attach the same meaning to the data elements in the message (B1 sub-problem). Also the exact response to a message sent (the B2 sub-problem), e.g. whether to pay within two or twenty days after the receipt of an invoice, depends on agreements between sender and receiver. Thus the meaning attached to a message is often laid down in a procedure shared by both organizations, and is not stated in the messages themselves.

Level C. The problem at level C is actually not a communication problem. If the meaning of a message (level B) is understood and agreed upon, the conduct or response of the receiver depends on his internal functioning. The level C problem deals with situations in which through some kind of disturbance the sustained effect of a message deviates from the desired or intended effect of the message. If a disturbance is foreseen, OUs may in the design phase decide to resolve its occurrence in a structured predetermined manner using specially defined EDI messages. This will be done if one expects a disturbance to occur frequently. Disturbances that cannot be foreseen or that are economically unattractive to be handled in a structured manner, will result in *mutual adjustment* between people of the different OUs as the mechanism coordinating the interaction. Designers must therefore allow for an informal communications channel (telefax, telephone, meetings) to run in parallel to the formal EDI channel. Coping with the inevitable *interference* between both channels is essential.

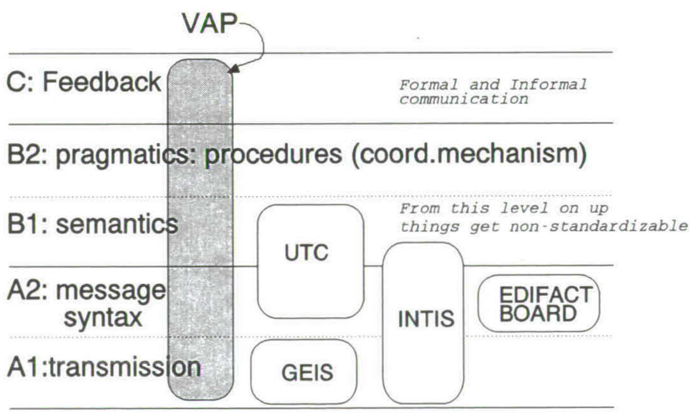

Figure 6.2 - Communication partitioning tool. EDI related standardization reaches level B1

In Figure 6.2 these levels of communication are depicted along with examples of organizations that try to standardize the several levels. The level B problem is also called the coordination problem and its solution, called a coordination mechanism, has been discussed in chapter four. The level C problem is a control problem transcending the boundary of a single organization. Actually this could be called a coordination problem, but in order to distinguish it from the level B problem we use the term feedback problem.

The level C problem: the dynamic versus static design guideline

Dealing with responses which are not in accordance with what was agreed upon at level B is actually a control problem. In the design of a control systems (see Nauta Lemke 1968) two separate designs can be distinguished: the static design and the dynamic design. The static design refers to the design of the process to be controlled. Relevant design variables are the throughput, the capacity, lead times, etc. The term static is a bit misleading since this design also considers the dynamics of the system, as long as no disturbances occur. The dynamic design accounts for that part of the system dealing with (or controlling) disturbances. Applying this distinction to two communicating organization, the solution to the level B problem is called the static design, while level C is dealt with by the dynamic design. In a logistics process all sorts of disturbances may occur, e.g. accidents, errors, exceptions. Whether or not to anticipate for a type of disturbance in the design phase of a Value Adding Partnership is an important design issue, especially when a formal means of communication such as EDI is used.

Guideline: ***For every process in a Value Adding Partnership a distinction should be made between the static and the dynamic design.***

An important issue in using this guideline is to find the balance between disturbances which are anticipated in the design phase and which will be handled in a formal way, and disturbances for which no solution is designed upfront and which will be handled in an informal manner as they occur. Frequently occurring disturbances are most likely to be dealt with in a formalized manner, while rare disturbances, though foreseen, will be handled in an ad hoc manner. We conjecture that there will always be unforseen disturbances and that therefore organizations must always allow for an informal communication channel in parallel to the formal one (see Figure 6.3). Procedures for resolving or even avoiding interference between the formal and informal channel are of utmost importance.

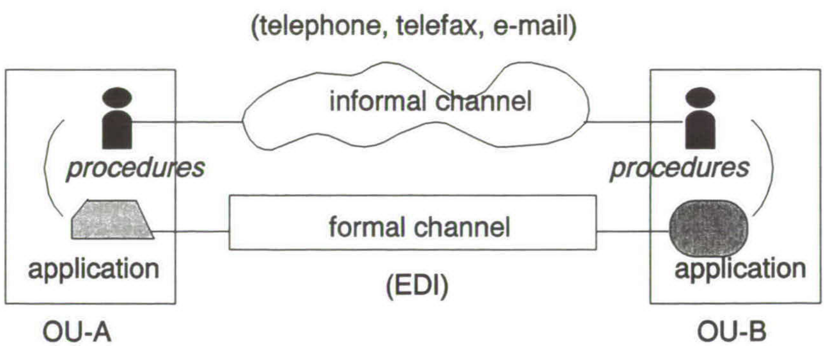

Figure 6.3 - Communication channels between OUs

Some coordination mechanisms dealing with the normal course of events (level B) but which are high in equivocality[1] (see chapter four) may not be formalizable and are also handled by an informal channel, e.g. joint design. These mechanisms, which require high bandwidth (not necessarily in the technical meaning of the term) communication channels, may also employ electronic means, e.g. *multi-media technology*, and should not be mistaken for level C communication. They are beyond the scope of this research.

Disturbances

The crux is finding those disturbances or exceptions to be dealt with in a pre-determined or even automated (by means of EDI) manner. Suppose that E represents the universe of disturbances, i.e. all possible disturbances, current and future. Setting up the dynamic design requires the following steps (after Williamson 1991):

(1) Prediction of possible disturbances, $\epsilon_1, \epsilon_2, .. \epsilon_i .. \epsilon_n$, which is a subset of E, since we are unable to foresee everything that can go wrong.
(2) Prediction of the variance (in magnitude or impact) of ϵ_i.
(3) Prediction of the frequency of ϵ_i.
(4) Selection of disturbances ϵ_i, for $i=1...k$, $k \leq n$, which can and will be dealt in a formalized manner.

This choice will depend on the balance between the cost of designing and implementing a formalized way of handling, viz a viz the cost of dealing with the disturbances in an ad hoc manner, during the life time of the VAP. The cost is a function of the variance and the frequency of the ϵ_i.

(5) Designing, i.e. formalizing and implementing the solution for dealing with ϵ_i, for $i=1...k$. This constitutes the dynamic design, and consists of the EDI messages and corresponding procedures.

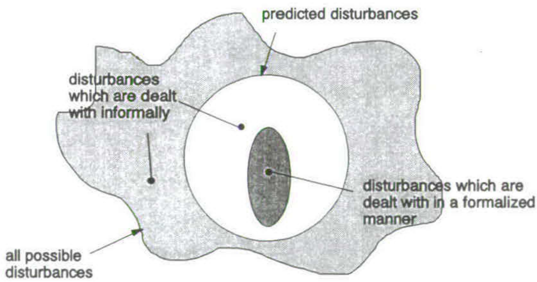

Figure 6.4 - Disturbances

Steps (1) - (3) above suggest that uncertainty may arise with respect to the type of disturbance, the variance of the type, and the frequency of occurrence of the type. Hence,

[1]This is consistent with Daft & Lengel (1986) who argue that equivocality requires richer communiation media.

even if one would decide to formalize the way of dealing with all n foreseen disturbances, the remaining uncertainty in the prediction of variance and frequency together with the unforseen disturbances in E, will result in a variety that exceeds the variety of the EDI channel. Ashby's Law of Requisite Variety (see chapter four) dictates that the communication channel must have equal or more variety than the disturbances. Because the variety in disturbances exceeds the variety of the disturbance handling messages and an EDI channel has a limited capacity/variety, there will be need for an informal channel

6.3 Organizations as communicating actors

The literature on language philosophy (Searle 1969, Searle & Vanderveken 1985) that studies the communication between human beings provides some very useful insights that are well applicable to the communication between organizations. This insight will help us understand the nature of messages exchanged by organizations, and will be presented in the form of a message classification. This approach is similar to the approach by Dewitz (1992) who has derived a classification of messages for legal (contracting) communication between organizations. Our classification of messages concerns formalized, i.e. to be interpreted by a computer application, logistical communication. A communication protocol specification tool will be developed based on the notion of the state of conversation (Winograd & Flores 1986).

6.3.1 A classification of messages

The following classification of messages serves the purpose of improving the understanding of the business designer. Concepts of speech act theory may help to understand the intended effect of messages.

Speech acts theory and communicating OUs
The basic idea on which this branch of language philosophy is based, is that humans can perform acts through speech, i.e. through the utterance of performative statements (as opposed to informative statements that merely describe the world around us). These acts are called illocutionary acts (one type of speech act). In general an illocutionary act consists of an illocutionary force F and a propositional content P, denoted as F(P).

Illocutionary point is one of the seven components of illocutionary force, and by far the most important one. Illocutionary acts with the same point may differ in the degree of strength of the illocutionary point. E.g. 'I request you to do this' and 'I insist that you to this'. As we are studying the formal communication between organizations, the illocutionary point of a message (we will use this term instead of utterance) has sufficient descriptive power. Propositional content is apparent in most messages between organizations.

Searle (Speech Acts 1969, and a Taxonomy of illocutionary acts 1975) classified all speech acts as embodying one of five illocutionary points. The five categories of illocutionary points are (from Winograd & Flores 1986) given in Table 6.2.

Table 6.2 - Types of illocutionary point

Illocutionary point	Comment
Assertive	Commit the speaker to the truth of the expressed proposition
Directive	Attempt to get the hearer to do something. This includes both "questions" (which can direct the speaker to make an assertive speech act) and "commands" (which attempt to get the hearer to perform some linguistic or non-linguistic act).
Commissive	Commit the speaker to some future course of action
Expressive	Express a psychological state about a state of affairs (e.g. apology, praise)
Declaration	Bring about the correspondence between the propositional content of the speech act and reality (e.g pronouncing a couple married)

Logistics messages

Next we present a classification of messages used in logistics communication and fit the messages into the categories of illocutionary point. Notice that all the messages may be formalized and exchanged by means of EDI.

- Order — a messages which directs the logistical process of the receiver (and which is laid down in his goal information)

- Report — a message reporting on an order or cancellation received and carried out or not (in the latter case the report is sometimes called a 'Rejection')

- Request — a message by which the sender requests the receiver to commit resources (e.g. time, space) or to perform a declarative act

- Confirmation — a message sent in response to a request (or an order in which case it is called an 'order acceptance') by which the sender commits himself (positive confirmation) or not (a negative confirmation).

- Cancellation — a message which directs (or attempts to direct) the receiver to ignore or delete a previously sent order

- Declaration — a message with which the sender changes the (non-physical) status of an (physical) object; the message does not report on a status change, but *performs* the status change.

- Plan — a message containing several directives (orders) for the logistical process of the receiver for a fixed period of time

- Data message — a message conveying status information of the sender's process to the receiver

- Inquiry — a message by which the sender induces the receiver to send him certain information (e.g. request for quotation)

- Reply — a message containing information resulting from an inquiry sent (e.g. quotation)

Stamper (1973) gives a classification of information in which he distinguishes descriptive from prescriptive information. Among the latter type he includes instructions, orders, rules. A drawback of this classification is that no distinction is made between a message (from sender to receiver) and information (something which is available to a user), which results in different entities belonging to the same class. In itself the distinction between descriptive and prescriptive in useful. Our goal information and the procedures and rules are of a prescriptive nature, while the remaining types of information in OUs are of a descriptive nature (see section 4.2).

Apart from the expressives category, all classes of illocutionary point are apparent in the communication between organizations (OUs). In the table 6.3 the messages classified are related to their illocutionary point.

6.3.2 The IR state diagram and a design guideline

In a VAP the OUs jointly control the goods flow between them. This joint control requires coordination through communication. In this section we describe a specification tool for the business communication protocol, the IR state, a way of describing this IR state, and some guidelines for its design and its use as a design aid.

What is the IR state?
The state of an OU includes among others its status base, which is it most important component. Each OU in a pair of OUs has its own state. The IR state is defined as the virtual state of the 'conversation' between the two OUs. Exchanges of messages and goods as well as some changes internal to an OU (these transitions are governed by shared procedures), alter this IR state. Hofman (1991) has used state transition diagrams to describe the states *one* organization can go through with respect to several messages exchanged in a transaction. Though related this is not the same as the IR state proposed

here, the difference being that the IR state presents the view *shared* by *both* organizations on the *object* of a transaction.

Table 6.3 - Message types and their illocutionary point

Illocutionary point	Messages type	Comments
Assertive	Report Reply	
Directive	Order Request Inquiry (question) Plan Cancellation	A plan comprises several orders, each with a different time attribute.
Commissive	Confirmation	
Expressive		No messages in classification
Declaration	Declaration	E.g. customs clearance, blocking/ releasing of inventory Be aware of the confusing terminology: the 'Customs Declaration' as it is called in practice is actually a 'Request for declaration' and thus of the message type Request.
(No ill. point) Informative messages (the others are performative messages)	Data Message	These messages have no function (illocutionary point) on there own. In order for them to be relevant to the receiver, some procedures must have been agreed upon in advance by sender and receiver.

The object of a transaction is simply the order, or the object stated in the order, that triggers the logistical process. E.g. in the order from a liner to a stevedore to load a container on a vessel, the container is the object of the transaction. The IR state concept reflects the virtual state of the communication (IAS) part of a boundary crossing process. The term "virtual" is used to emphasize that the IR state does not represent the "actual" states of the organizational units involved. Messages are looked upon either as input or output of a "virtual machine" before they are passed to the receiver (see Annex 6.I for a description of such machine). The state of this virtual machine is called the IR state. This is depicted in Figure 6.5. The procedures and rules agreed on by both parties which are used in the coordination of the goods flow are seen as part of the IR state machine. Input messages, or procedures or time-stamps (as in the case of coordination by plan) trigger state changes.

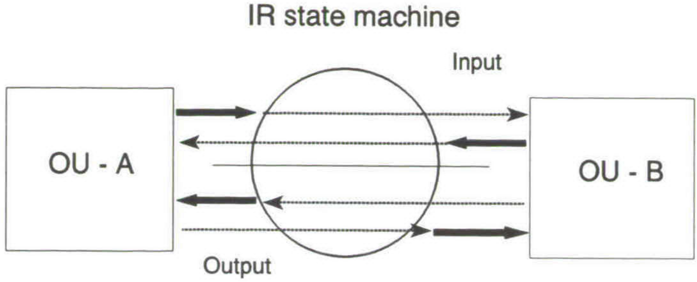

Figure 6.5 - Exchanges between OUs are perceived as in- or output of the IR state machine

The IR state diagram is a design aid. Business designers from both OUs should determine:
- what the states are,
- which transitions are allowed, and
- how they will be supported.[2]

After the design phase, in the implementation phase, the resulting IR state diagram serves as a specification of the business communication protocol. The following guideline pertains to the IR state.

Guideline: ***For every transition in the IR state diagram a message or procedure needs to be defined.***

Transitions that are not supported adequately by messages or procedures may result in differing views on the state of the communication, which in turn may result in errors.

Guidelines for setting up the IR state

For every basic mode of ordering the IR state diagram is given. These diagrams can be used as the point of departure by business redesigners setting up their IR state. But first a generic form of the "machine" states will be derived.

The generic form of an IR state

Regardless of the coordination mechanism used we can identify an order in every logistical process. The way the order is generated and how it relates to the delivery of the product is called the *ordering mode*. In the case of planned and continuous ordering mode the order is exchanged explicitly. In the case of the shared variable ordering mode the order is generated by some procedure, as follows:

$$\text{Order} \leftarrow (\text{Procedure (variable shared)}).$$

[2] The size of the IR state diagram can be looked upon as the degree of insight OUs have in each other's operational processes.

An order is of the following form:

Order = { Action (T, X) PO }

where
- T is the start time and/or completion time of the logistical action elicited by the order
- X specifies the place (places) where the action is to be performed
- PO is the physical object on which the action is performed; the PO has at least one relevant attribute.

Consider the following generic VAP in which A is the superior and B is the subordinate: orders are given by OU_A to OU_B. On receipt of the order B checks whether it can perform the order and sends a message accordingly. At some point in time B starts performing the order and after completion sends a report to A. Recall from chapter three that every logistical process is triggered by an order, implicitly of explicitly. The IR state for this VAP consist of one attribute "Order_Status" which can resume the following values:

- 0 (initial state)
- order requested (r)
- order pending (p)
- order completed (c).

The corresponding IR state diagrams for each ordering mode are given in Figures 6.6 - 6.8.

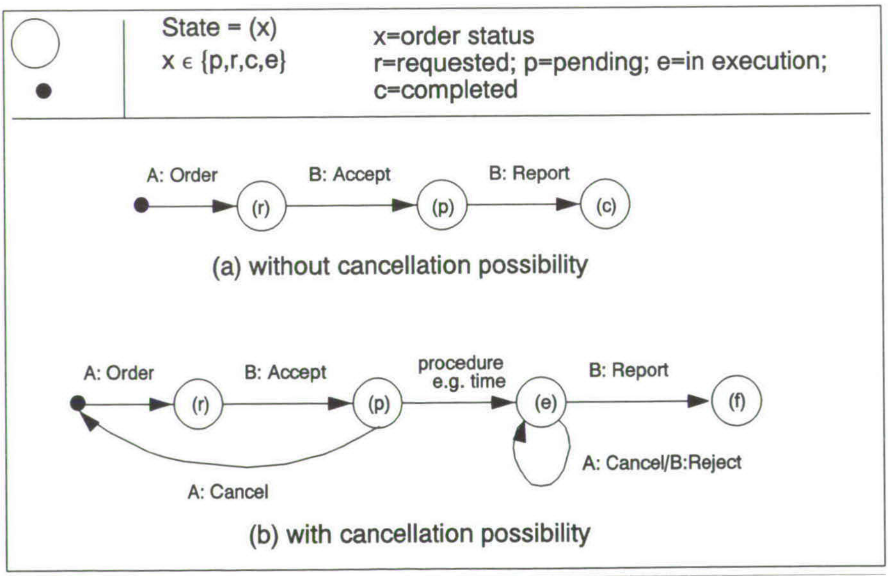

Figure 6.6 - The IR state diagram for the continuous ordering mode

Figure 6.6.a applies to a continuous ordering mode without cancellation possibility. In order to allow for cancellation, in Figure 6.6.b the state Order_Status = "Order in execution" is added. In a VAP an order is usually accepted by the subordinate immediately, so that instead of the transition pattern "● → (r) → (p)" the diagram will have the pattern "● → (p)" and the message B: Accept will not be exchanged. The input of the IR state machine of Figure 6.6.b is

$$I = \{ \text{Order, Accept, Report} \}$$

while the output for the case without cancellation possibility is empty and in case of cancellation possibility it is

$$O = \{ \text{Reject} \}$$

The IR state diagrams for the shared variable and planned mode of ordering are depicted in Figure 6.7 and 6.8 respectively.

The IR state in the Figures 6.7 - 6.8 is determined by one status attribute "Order_Status" which can assume three (or four) values. The object of a transaction may also include the PO (physical object) status specified in the order. Especially in service VAPs where the action will be to move or pack an already existing PO, the status of the PO will determine whether the order can be accepted (see the case studies in chapter seven).[3]

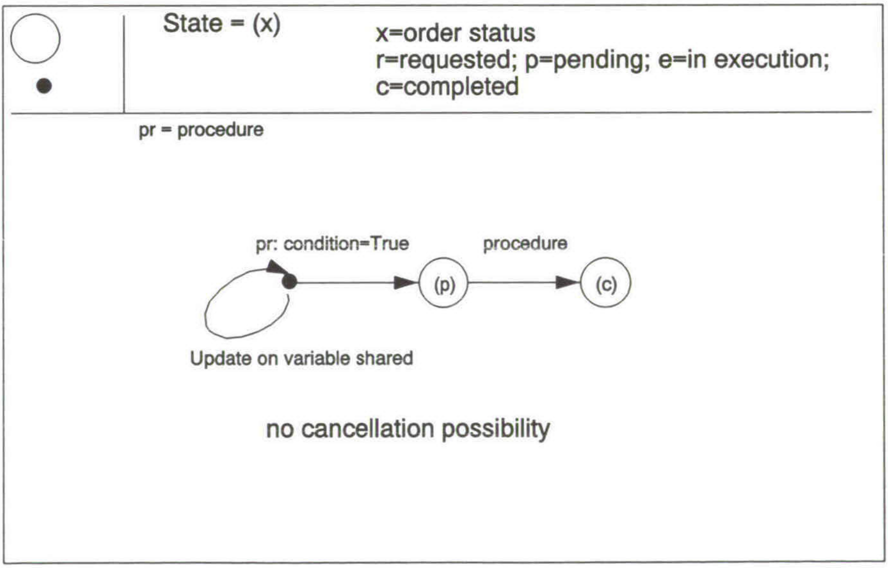

Figure 6.7 - The generic IR state diagram for the shared variable ordering mode

[3] We cannot give generally applicable rules for selecting the state attributes and relevant transitions. One could question whether this is useful, since the attributes are very specific to the logistical process and the physical objects therein.

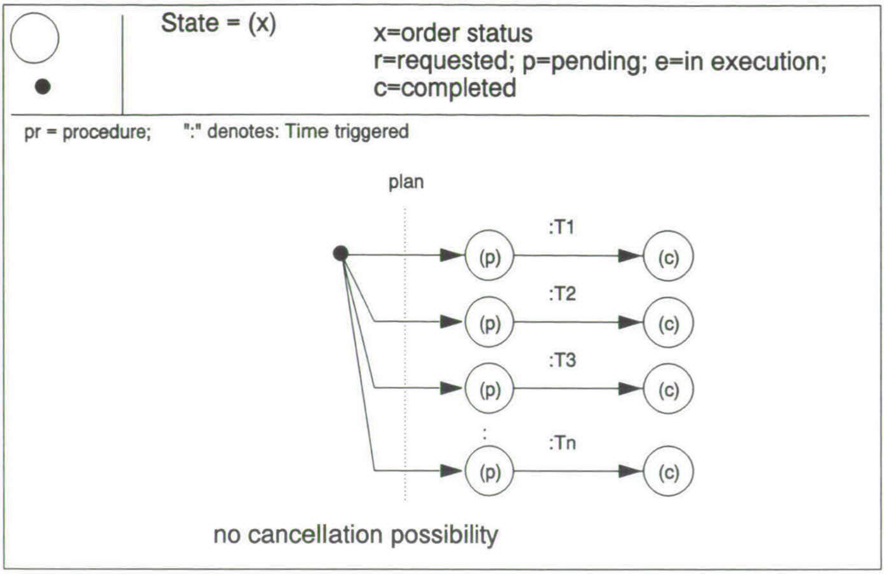

Figure 6.8 - The generic IR state diagram for the planned ordering mode

The IR state diagrams above are referred as the *communication design tool.*

6.4 An integrating method

The term methodology has two different meanings. On the one hand the term is used to refer to a process to be followed for obtaining knowledge, e.g. a scientific methodology. The term also refers to a set of methods for interfering with or changing reality. It is this latter meaning which is applicable to this section. The purpose of the following method is to help the business designer using the theory presented in chapters four and the knowledge on design of the previous sections, by providing him with an integrating framework for approaching his design problem.

This method applies to the design of a VAP after the strategic decision to enter the partnership has been made and the contract governing the partnership has been drawn (see Figure 1.6 and Figure 6.9)). As pointed out earlier, we are not concerned with partner search and selection, but with the design of the inter organizational relationship at an operational level, especially the EDI communications part of the operational design. The method should support the business redesigner in:

(1) identifying the core processes to be coordinated,
(2) spotting areas of EDI induced potential for (re)design,
(3) designing the business communication protocol.

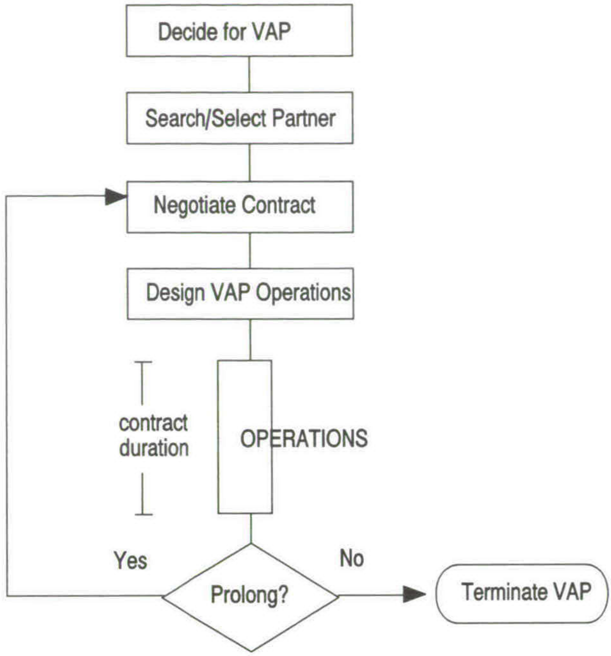

Figure 6.9 - The lifecycle of a VAP

These objectives of the method and the knowledge and tools developed for achieving these objectives are summarized in table 6.4.

The method thus integrates the parts of this study which or are of direct or indirect relevance to the business (re)designer. A method cannot be true or false. It can only be more or less useful depending on its effectiveness and/or efficiency. These characteristics can only be ascertained through repeated application. We propose the following method based on our experience in the case studies, our theory, and the imagery of the previous paragraphs, but will make no attempt to assess its usefulness.

Table 6.4 - The Objectives of the method and corresponding Knowledge and Tools

Method Objective	Knowledge/rules	Tools
(1) Identifying core processes	Process view (§ 5.1)	Graphical language
(2) Spotting EDI induced redesign opportunities	EDI capabilities (§ 4.5) Coordination theory (ch. 4) Design guidelines (§ 4.5)	Data diamond
(3) Designing communication protocol	IR state guideline (§ 6.3) Static/dynamic design guideline (§ 6.2)	Communication design tool Communication partitioning tool Simulation Tool

A method for operational VAP design

Design involves creativity and there are many designs which can fulfil a given set of design specifications. In spite of the creativity intrinsic to design, method may speed up a design process and improve the quality of its product. (There are even methods that support creativity.) In general three steps are taken in designing a system (Rolstadas *et al.* 1991):

- a synthesis by selecting appropriate elements and connecting them into a system,
- an analysis to control, from basic laws and in a computational manner, that the estimated system satisfies the requirements ("customer/design specifications"),
- an optimization aimed at selecting the best alternative according to some criterion (performance indicator).

In our method the synthesis and analysis, or evaluation as we prefer to call it, are iterative stages in the VAP (re)design project. Optimization is not part of this methodology. This requires some mathematical rigor which this study has not yielded, and which is hard to obtain in the design of real business systems.

This method which integrates all the deliverables of this research and brings out the coherence among them is given in Table 6.5. A graphical depiction is given in Figure 6.10.

Final remark

As was stated earlier the method just presented is derived from the theory presented earlier, the guidelines derived in this chapter, and the experience obtained in two real life case studies. The method has not been subjected to empirical test, although parts of it will be illustrated in the case studies of the next chapter. Ideally this method should be part of a continual cycle of application, evaluation, and elaboration. Elaboration not only implies enhancement of the existing tools, but also the development of new tools. As the theory of logistics coordination develops, it also likely that this new insight will change and/or add steps to the method.

Table 6.5 - An integrated method for VAP design

Phase I - Set target

Step I-1: Create vision;
Determine key performance measures;
Set required performance for (a) the VAP as a whole
(b) between OUs

Phase II - Internal design

Step II-1: Identify core boundary crossing processes
Step II-2: (fep)
Assess distribution of physical and internal control tasks;
redistribute (reengineering) if desirable

Phase III - Status Quo Reengineering

Step III-1: Assess sources of IU and GAS uncertainty, and their impact on BU
Step III-2: Determine the level of BU which is acceptable, and based on this
Step III-3: Design the coordination mechanism (use data dependency diamond)
a. decision making aspect
b. communicating aspect

Phase III - Breakthrough reengineering

Step III-4: Assess DoF and search for lowering measures
Step III-5: Assess $Var(M_i)$ for both OUs and search for increasing measures

Phase IV - Design communication (1): Level B (Static)

Step IV-1: Level B (static) design; use communication design tool (IR state diagram)
use communication partitioning tool

Phase V - Evaluation

Step V-1: Use simulation to evaluate
a. distribution of tasks
b. coordination mechanism (e.g. frequency)
c. performance

Phase VI - Design communication (2): Level C (Dynamic) & Detailed

Step VI-1: Level C (dynamic) design; use communication design tool (IR state diagram)
Step VI-2: Detailed message design

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fep = for each process

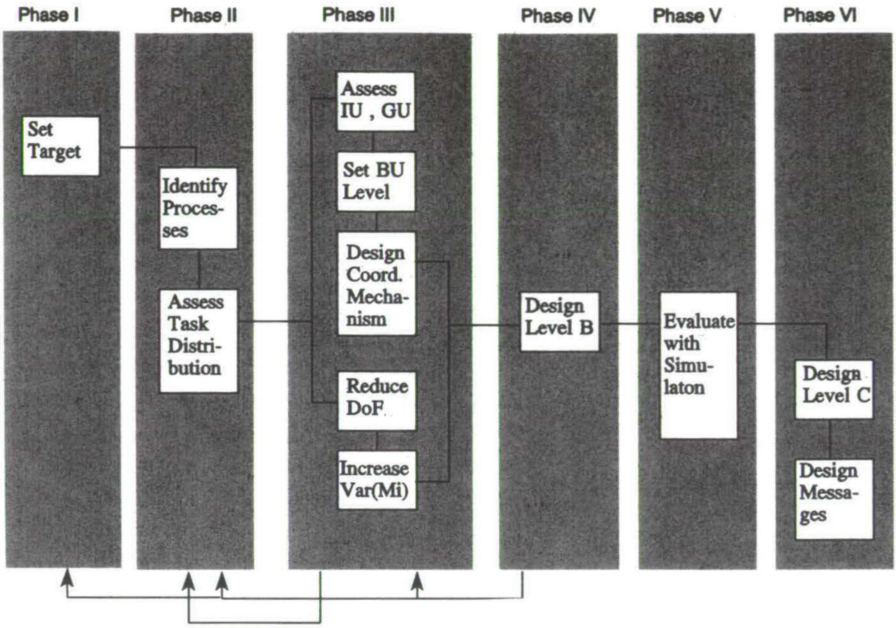

Figure 6.10 - A method for VAP (re)design

Chapter Seven

Empirical research

"Scientists with creative imaginations are ever confronted by two opposing forces. One tempts them to soar into the realm of fancy, and the other cautions them to keep their feet on the ground."
- **William Seifriz,** 1943

Two case studies were conducted in parallel with the development of the theory and the framework for modeling logistics. The purpose of these studies was on the one hand to get a feeling for practical issues in VAP design (both the verb and the noun), and on the other hand to test and illustrate the theoretical and modeling contribution of our study. In a third case, a consultancy engagement, the knowledge that resulted from our study was applied from a business consultant's point of view. In the case descriptions we will illustrate the expressive power of the modeling framework; apply the design guidelines, tools, and method; and bridge the gap between our theoretical description and practice (make the material claim).

7.1 Introduction

Research in business administration should ultimately fulfil a practical purpose. The case research described in this chapter helped formulating and justifying the practical aim of our study: supporting the (re)design of VAPs. The transport case (section 7.3) in which we were involved during the design phase of the VAP has made clear the costliness of the design process, and hence the need for support that might speed up this process and improve the quality of the resulting design. The deliverables of our study (see Table 2.1) are chosen on the basis of observations made in real life cases. Apart from this exploratory purpose of the case research, its illustrative purpose is considered to be very relevant. The case descriptions below should illustrate the applicability of our modeling approach, and give substance to our theoretical constructs. Further, situations will be described in which the relevance of the tools and guidelines becomes pertinent. Also in the case research we let the theory 'work' in reality, i.e. reason on the basis of our theoretical insight about the coordination mechanisms of the VAP, and on the potential of redesign through further uncertainty reduction. A third purpose of the case descriptions is their exemplary function. Future VAP designers of similar as well as dissimilar cases, can learn from the way the designers in the following cases approached and solved their design problems.

Case research design

Table 7.1 gives our case selection (see section 3.3 for the classification of logistical systems). The first two case studies have an exploratory and illustrative emphasis, while in the third case the knowledge is applied from a business consultant's viewpoint.

Table 7.1 - Case Selection

Case	VAP type	Life cycle	Method	Case focus
1 Physical Distribution	PLS-SLS	Operational phase	Interviews Document Analysis	Illustration Exploration
2 Transport	SLS-SLS	Design phase	Interviews Participation	Exploration Illustration
3 Sourcing and Distribution	PLS-MSLS SLS-MSLS	Visioning phase	Consulting	Application

PLS = producing logistics system SLS = service logistics system MSLS = mediating SLS

Both *comparison* and *application* (Van der Zwaan 1990, p.148) are used in the cases. Comparison between the empirical case data and the theoretical picture of logistical coordination illustrates and operationalizes the theory. 'Application' is used to illustrate that the knowledge on design leads to design improvements. The following *questions* have guided the reporting of the case studies.

(a) Can you map the theoretical constructs and the modeling language on reality?

(b) Can you reason about the VAP design, based on the insight provided by the theory?

- (b1) are there opportunities for boundary uncertainty (BU) reduction?
- (b2) can the degree of freedom (DoF) be reduced or the variety in action ($Var(M_j)$) be increased?

(c) Is the knowledge on design useful in the case?

7.2 A case study in physical distribution

In this first empirical case we were involved during the operational phase, i.e. the VAP had been designed quit recently and was 'up and running'. For the manufacturer in this case the experience of a VAP was a first time experience, while for the logistics service provider it is core business to develop close relationships with other organizations in order to provide the best service possible.

7.2.1 Introduction

Object of this case study is the VAP between PTT Post Logistiek (PPL) and a leading cosmetics manufacturer, further referred to Beauty Cosmetics (BC). PTT Post Logistiek is a business unit within PTT Post B.V. providing an integral logistics service for pallet and for parcels up to approximately 35 kg and of restricted volume. They provide this service to organizations wishing to outsource (parts of) their logistics function, by forming what is called a value adding partnership (VAP). The partner in this case study is Beauty Cosmetics, a producer of hair cosmetics. Beauty's activities include, besides production and R&D, the marketing, sales, and distribution of their products.

Beauty decided to outsource the distribution to PPL when they faced with a capacity problem in their own warehouse. They had to choose one of two options: expanding and continuing with the old way of working, or outsourcing the distribution to a third party. Beauty used to perform part of the distribution themselves, and part of the transport was performed by carriers. The quality of the latter, which was not very good, and market trends placing emphasis on logistical performance were amongst others the reasons for entering into a VAP with a specialist, with whom clear logistical performance measures could be agreed upon.

PPL and BC have established a three year contract governing the physical distribution service delivered by PPL starting from November 1, 1991. The service comprises the warehousing, transport, and distribution of goods to Beauty customers (or customer's distribution centres). The warehouse of PPL is called a logistics centre (LC) and is located in Etten-Leur. On a high level of aggregation the situation is as depicted in Figure 7.1. PPL is responsible for transporting the products from Beauty's production plant to the LC (a distance of approximately 75 kilometres), the warehousing and the transport and distribution to the Beauty customer. In principle all of Beauty's finished goods inventory is located at the LC, apart from a small buffer inventory at the plant, called expedition inventory.

The role of the "collection/distribution network" (Figure 7.1) is on the one hand to collect and transport goods from Beauty to the LC, and on the other hand to deliver customer specific shipments to the customers, within certain performance constraints. The constraints for the transport from Beauty to LC is that the transport must be direct, while the constraints for the distribution part of the network are that goods which leave the LC today before 17:00 hrs, must be at their destination the next day (one day delivery service). The distribution part of the network encompasses a pallet transporter which delivers pallet directly to the (large) customers, and the postal network of PTT Post containing several sorting centres for parcels. Even though the functioning of this network is part of the service PPL delivers to Beauty, and subsequently part of Beauty's customer service, in this study these performance constraints are viewed as being fixed and it is assumed that the network fulfils them. Strictly speaking, the relationship between PPL Etten-Leur and the "network" is a second VAP, which could be looked upon as a second case study. Therefore in the remainder of the study we will treat the network as a black box. Disregarding the "network" results in the aggregated situation of Figure 7.2.

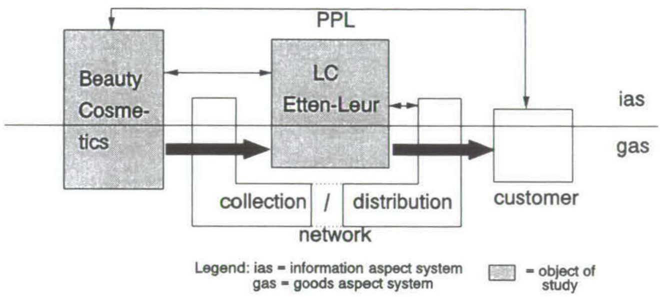

Figure 7.1 - The Setting of the Object of Study

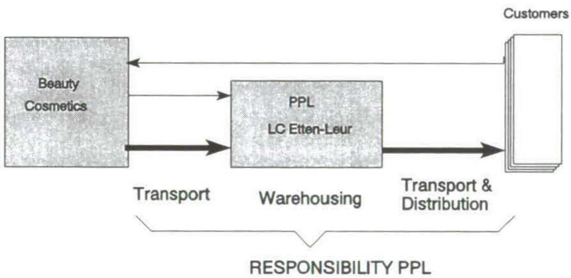

Figure 7.2 - Block diagram of the value adding partnership studied

PPL and Beauty have agreed on a 48 hours delivery service, meaning that customer orders which are 'relayed' to PPL on day one are delivered to the customer before day three. PPL has to conform to the following logistical performance measures, which have been laid down in the contract:

- delivery reliability $\geq 99\%$;
- errors (due to picking or handling) $< 0.5\ \%$ of the number of shipments.

One way to measure this performance is the 'customer complaints registration' system using as performance indicators the number of customer complaints and the number of goods returned. This part of the customer service is the responsibility of PPL. Other components of the customer service such as product availability and product quality are the sole responsibility of Beauty, and therefore not specified in the contract between the parties.

The organizations currently use EDI for the communication of seven messages, and unstructured means for the remaining eight messages (see Annex 7.I). In order to distinguish the current batch EDI communication in which the X.400 Net is used as the infrastructure from real time EDI we will refer to this communication as e-mail[1].

We will first describe the processes between the two OUs. This description is followed by a theoretical analysis, i.e. is subjected to our theoretical constructs, the purpose of which is to operationalize our constructs for this specific case. Finally the practical guidelines and tools are applied.

7.2.2 Process descriptions

Beauty produces to stock on basis of a Sales Forecast[2]. The actual production planning is not of interest in the analysis of this logistical process, especially since the production lead times (at least 5-7 days) are long compared to the required customer service level (delivery time of 2 days). The production process consists of two steps, the first of which is the physical production of the goods resulting in the 'blocked' Finished-Product (FP) Inventory. The second step of the production process is the quality-control step in which samples of the production batch have to be tested bacteriologically. If the batch passes this quality test, the goods are released and become 'unblocked' FP-Inventory. These unblocked goods, which may now enter the market, are physically moved to another location in which the Expedition-Inventory resides. The goods at the LC are referred to as LC-Inventory. Beauty is responsible for the inventory levels in the LC.

There are two logistical processes in the chain of Figure 7.2: one pertaining to the replenishment of the LC with goods, the other pertaining to the delivery of orders to customer as are shown in Figure 7.3.

The delivery-process starts with a CUSTOMER_ ORDER from the customer and has two ending points: the receipt of a message from PPL (REPORT) that the goods have been

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[1] This is not correct since the communication of these messages adheres to the definition of EDI which is "the exchange of structured messages between in-house applications of different organizational units by electronic means". The time lapse between sending and interpretation of messages is beyond the definition.

[2] For some customers of private labels (e.g. some of the main retail chains) BC produces to orders which are placed in advance. Since this has no bearing on the interface with PPL this extra complexity in the BC production process will not be discussed.

picked and delivered to the "network", and the actual delivery of the goods to the customer. As was explained in the introduction we consider the "network" a black box and assume that it conforms to the 'next day delivery' performance measure. Reason why only the first end point of the delivery process is depicted in Figure 7.3.

The replenishment-process starts with the selection by the Beauty warehouse/expedition manager of the goods in expedition inventory to be transported to the LC. These goods are listed in a SHIPPING_LIST to PPL. The replenishment process ends with the message from PPL that they have received the goods, and added them to their inventory.

These processes are loosely coupled. The coupling manifests itself when goods ordered to be delivered to customers are not in the LC, but are available in the buffer or expedition inventory at the Beauty's plant. The processes are depicted in Figure 7.3. (In this representation of the processes no distinction is made between information flows and goods flows.) The process decoupling point is thus the physical inventory at PPL. A detailed description in term of our modelling approach (see section 5.2) is given in Annex 7.II.

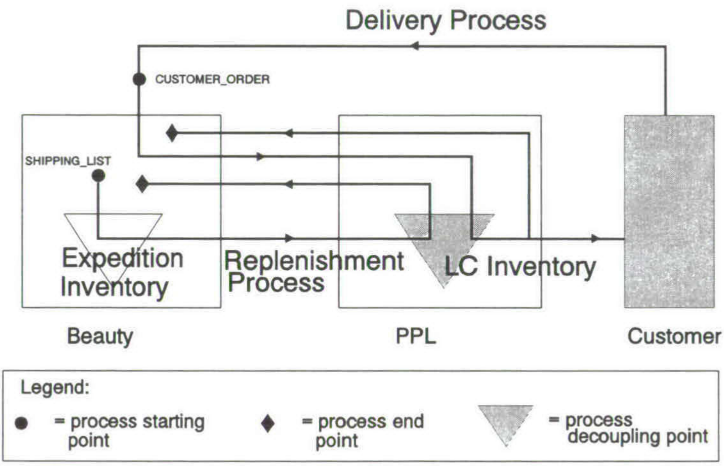

Figure 7.3 - The two loosely coupled processes in the VAP

We will next describe:
- the data administration layers,
- the two boundary crossing processes, and
- a practical problem in the design, called the synchronization problem.

The table containing the messages used between Beauty and PPL given in Annex 7.I facilitates the reading from here on.

The data administration layers

The data administration layers of the layered organizational model (LOM) are given in the following tables, in accordance to the data typology derived in chapter four. Only the information relevant for our description and analysis is given. We did not encounter any type of information which did not fit our typology, and may conclude that for this case the typology works.

The data administration layer of Beauty contains the orders that need to be delivered, which is goal information. The database also keeps track of the status of an order, e.g. whether it has been sent to PPL, and whether PPL has reported its delivery. The Cust_Specifics contains special instructions pertaining to the delivery of a shipment for a particular customer, e.g. never deliver to customer X on mondays. This database is part of the model information, together with the database on customers (Cust_base), the article number base (ArticleNrs), and the description of the consumer units as they should appear on the packing slip (CE Description). The FP-Inv denotes the finished product inventory, of which each pallet may be blocked or unblocked. Expedition inventory is inventory that may be shipped to PPL. This inventory is also physically separated from the FP-inventory. The In-Transport Inventory represent the shipments in the replenishment process, i.e. shipments that are not yet stored and reported back on by PPL. A very important database within Beauty is the LC-Admin_Inv which is of the coupling information type. This represents the inventory level at PPL, on the basis of which Beauty accepts customer orders. For each order accepted this level is decreased accordingly. The LC-Admin_Inv database is reconciled with that of PPL once a week, the latter being the leading database.

Table 7.2 - The Beauty data administration layer (only relevant data shown)

GOAL	PROCESS		COUPLING
	STATUS	MODEL	
C_Orders	FP Inv Exp. Inv. In_Transport Inv.	Cust_Specifics Cust_base ArticleNrs CE Description	LC-Admin_Inv_Level

The PPL data administration layer contains as status information the Inv_Level, along with for each pallet its location. Furthermore coupling information on the Beauty model is needed in order to interpret the orders sent by Beauty and execute them correctly, especially when customer specific delivery conditions apply. Of course the orders received and their status are stored as goal information in the OrderBase.

The LC replenishment process

Every day Beauty ships two or three truckloads of goods to the LC. These goods are transferred from the Expedition-Inventory level to the In-Transport-Inventory level in the data administration layer of Beauty. The moment a truck leaves Beauty a SHIPPING_LIST is faxed to the LC[3], specifying the pallets, each with a unique identification, that have been placed in transport. At the LC the message is used to determine the locations where the pallets will be stored, so that by the time the truck arrives, work orders for the forklift chauffeurs are ready stating the exact location where the pallet must be stored. The pre-information thus leads to concurrency in this process: the determination of pallet locations and the driving from the plant to the LC are conducted in parallel.

Table 7.3 - The PPL data administration layer (only relevant data shown)

GOAL	PROCESS		COUPLING
	STATUS	MODEL	
OrderBase	Inv_Level		ArticleNrs CE Descrip Cust_Base

After having stored the goods, the Inventory_Level is updated, and the intake is reported with the INTAKE_REPORT message to Beauty by phone (every day at 14:00 hrs according to the Manual). Under the contract PPL has to report the intake within 48 hours. With the current practice this is performed within several hours. At receipt of the INTAKE-REPORT that particular shipment is transferred from the In-Transport-Inventory to the LC-Admin_Inv_Level, meaning that the goods are now available for sales.

The customer delivery process

From Figure 7.3 it can be observed that both processes in the VAP are boundary crossing logistical processes. Because of the complexity of the delivery process its description is divided into two parts, one for each OU through which the process traverses.

Part 1 - The start trajectory within Beauty

Beauty receives customer orders by phone, fax, telex, TRANSCOM[4], or via a sales representative's terminal. The order types are depicted in Table 7.4. From here on the process for normal orders (which accounts for 95 % of all orders) will be described, unless a specific reference to the other order types is made. Orders consist of order lines, for each article ordered a separate line containing the specification of the article and the number ordered.

Order acceptance and entry. Beauty relays the accepted (individual) customer orders (C_ORDERS) which are accepted to PPL. All orders entered into the Beauty information system before 14:00 hrs are sent in one batch to PPL. Due to this event, the order entry

[3] This is where the pre-information capability of the fax is used. With respect to this capability there is no difference between a fax and EDI. If however the message needs to be processed before it becomes information, the "speed of processing" attribute of EDI makes it an superior alternative to the fax.

[4] Only two customers are on TRANSCOM; orders are printed and reentered into the BC information system.

process at Beauty has two time windows during which different procedures apply: from 8:00 hrs - 14:00 hrs and from 14:00 hrs - 17:00 hrs. In the first time window all orders by phone or fax are checked against the Admin_Inv_Level data entity which is a reflection of the physical inventory in the LC, and which is decreased accordingly. If there is not enough inventory for an article that order line is deleted or taken into backorder (this is done only for ± 10 % of the customers). If during this time window an article runs out of stock, it is indicated on a board in the room where the orders are entered, for use in the second time window: orders for articles on the board are not accepted.

After 14:00 hrs, i.e. in the second time window, orders are only accepted (on paper), but not entered into the system. These accepted orders will be entered the next morning, and are relayed to PPL with the batch of 14:00 hrs of that day. If the LC stock depletes as a result of orders coming in after 14:00 hrs, the sales manager will check if there is buffer (expedition) stock in the Beauty Warehouse, or blocked Finished product inventory which can be taken out of the blocked state. These items will be transported to PPL early the next morning as a rush intake (Du: spoedinslag), meaning that they will have to be entered into the PPL system, and reported back to the Beauty system before 12:00 hrs. With the report of the intake, the INTAKE-REPORT message, Beauty can update the Admin_Inv_Level accordingly, so that orders can be accepted by the system. There is then enough time to enter the orders so that they can be relayed to PPL with the batch of 14:00 hrs.

Table 7.4 - Type of orders[5]

Type of order	% of total	Delivery conditions
Rush order	4 %	Customer Order received before 12.00 hrs is delivered next day
Normal order	95 %	Customer Order received before 14:00 hrs is delivered in two days else three days
Term order	1 %	Customer Order given at least 10 days in advance; Order to PPL four days before delivery date

The inventory level against which a customer order is checked, Admin_Inv_Level, should[6] reflect the physical inventory in the LC. This is the inventory from which the orders are picked. Beauty relays all orders received before 14:00 hrs from customers once

[5] The figures in this table are probably no longer accurate, since at the time of data collection there was a tendency towards more term orders and less rush orders. The figures are included to give the reader an impression of the share of order types in the total amount of orders.

[6] "Should" because the administrative inventory at BC and the administrative inventory at PPL may get desynchronized, as can the administrative and physical inventory at PPL. This problem will be elaborated upon later.

a day. Due to processing and transmission time this batch of orders arrives at PPL at approximately 16:00 hrs.

Rush Orders. Customers wishing to receive their order the next day can place rush orders to Beauty till 12:00 hrs. These orders are relayed to PPL at 12:00 hrs and are picked the same day and delivered the next day (see Figure 7.4). Since there may not be rush orders every day, a telephone call is made to PPL to prompt them that they should empty their mailbox.

Part 2 - The trajectory within PPL
At receipt of the order batch (ORDERS) PPL makes a planning of the required capacity to pick all the orders the following day (see Figure below for the timing). All incoming orders are matched against the standing data (article, consumer unit, and customer bases). If e.g. a new article- or customer code is unknown to PPL an ERROR-LIST is faxed to Beauty and matters are resolved by phone. These standing data bases are updated once a week by means of e-mail messages (messages 1. - 3. in annex 7.I). The orders are matched against the inventory level. If for a particular order line the number in stock is not sufficient that order line is deleted, and Beauty is informed of this fact as soon as possible, by means of the NON-DELIVERABLE-ARTICLES message (fax and phone). Beauty will block that particular article, i.e. no more orders for that article will be accepted by the sales administrators.

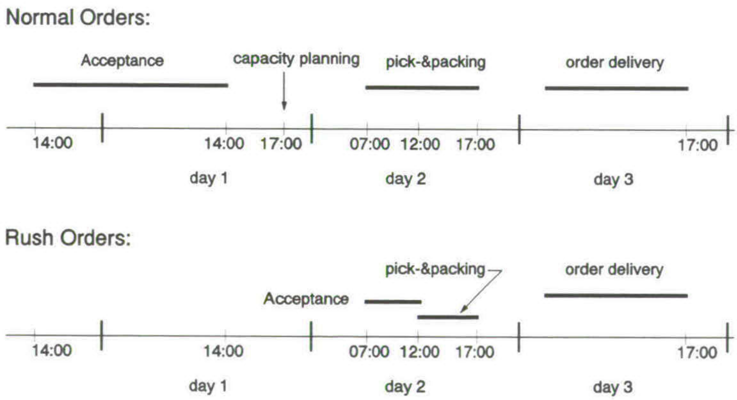

Figure 7.4 - The timing of normal and rush orders

After this inventory check picking lists are printed and made available to the order pickers at day 2 by 7:00 hrs. If during order picking inventory gets depleted as a result of a mismatch between the administrative and physical inventory in the LC, Beauty is notified of this fact by means of a PICKING-DIFFERENCES message. At the end of the day when all orders are picked, trucking capacity is ordered from the PTT Post Network for parcels and from the pallet transporter for pallets. Orders are reported back to Beauty by means of the REPORTS message stating the actual numbers picked, the next morning at 8:00 hrs by e-mail. Beauty uses this information amongst others for their invoicing. The time scale at which the above mentioned events take place is depicted in Figure 7.4.

The synchronization problem

The main problem facing organizations in a VAP who use linked databases is that the databases may get desynchronized, i.e. they become inconsistent as time passes. The variable of interest in this case is the inventory level. The standing data (AE base, CE base, Cust. base) can also desynchronized, but the problems resulting are minor. The three "inventory levels" of interest in this case are depicted in Figure 7.5. In both OUs the inventory levels are used and updated. The causes of desynchronization are:

- human mistakes in data entry;
- physical damage of products in the LC which go unreported to Beauty or even within the LC;
- temporary misplacement of goods in the LC;
- bypassing of the information systems (informal communication).

The two administrative inventory levels are synchronized once a week on mondays, by means of the ADMIN-INVENTORY-LC message. The administrative inventory level of PPL is adopted by Beauty, the rationale being that PPL's view on what is physically on their premises should be leading. The differences between databases are registered and resolved periodically.

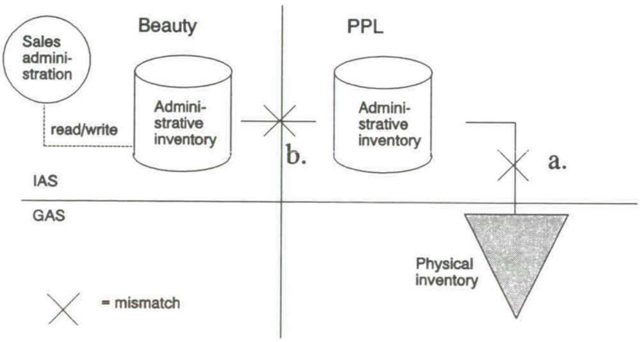

Figure 7.5 - The three important inventory levels

7.2.3 Illustration of design support guidelines

In chapter six two tools with guidelines were discussed. One dealing with the state of 'conversation' between OUs. A communication design tool state was proposed, and the guideline "every state transition must be supported, either by a procedure or a message" was formulated. The other guideline "distinguish between level B and level C" communication aims to structure the design process for the VAP designer. So does the first guideline, but it additionally provides an extra consistency of design check. We will next discuss the IR state diagram for Beauty and PPL, and the level C communication.

The IR state diagram

The *object* of the transaction in the customer delivery process (process II) is the *customer order (line)*. The IR state is comprised of the following attributes of this object:

- the status of the order line, x
- the deliverability according to PPL's administrative inventory level, y
- the status of delivery with respect to its completeness, z.

Thus, for the delivery process (process II) the IR state is a triplet (x,y,z), where:

$x \in \{p,c,r\}$	with	p=pending, c=completed, r=rejected;
$y \in \{0,1\}$	with	0=not enough administrative inventory, 1=sufficient administrative inventory;
$z \in \{0,1\}$	with	0=orderline only partially delivered, 1=orderline fully delivered.

The resulting IR state diagram is depicted in Figure 7.6. In section 6.3.2 the notation used in this diagram is explained. The guideline that every transition must be supported by either a procedure or a message is nicely adhered to in this case (in the case of section 7.3 we will discuss a situation where this was not so.)

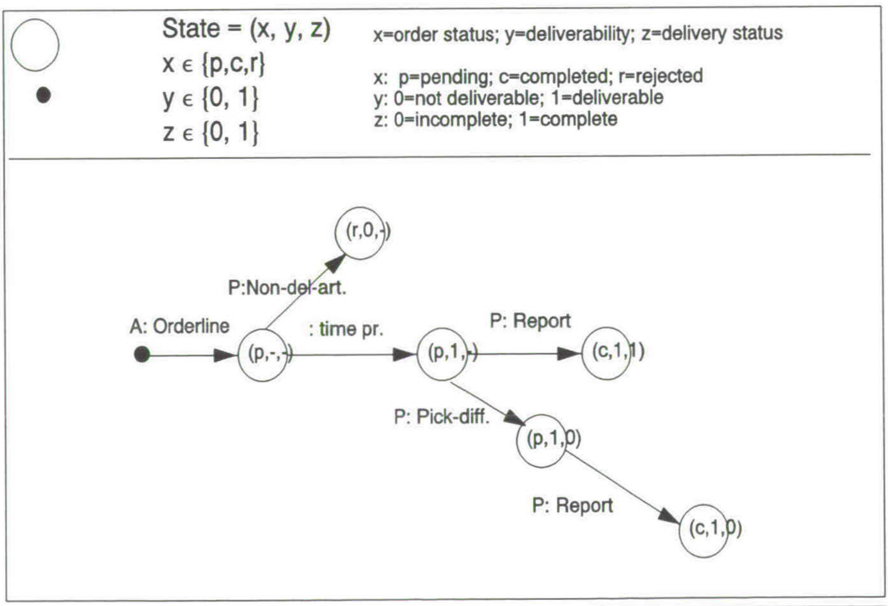

Figure 7.6 - The IR state diagram for the customer delivery process

Level B and Level C design

In this section the rather theoretical distinction between Level B and Level C communication derived from the communication stack by Weaver (1949) is applied to the PPL-Beauty process design (see section 6.2). The *Level B* design deals with situation in which the receiver of a message reacts as is intended by the message. The *Level C* design deals with disturbances. The distinction between Level B and Level C design is considered very relevant to the VAP designer, for it helps him to 'see the forrest for the trees' whilst in the middle of his design effort.

Level B design

The delivery process in case there would not be any disturbances is given in Figure 7.7 (the data administration layer is not shown).

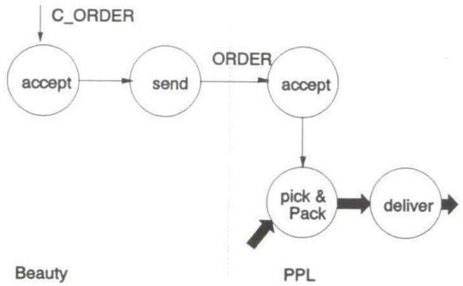

Figure 7.7 - The Level B design of the delivery process

Notice that at Level B only orders are exchanged. Beauty relays a customer order to PPL, PPL ships the entire order the next day. The delivery time has been agreed in the procedures which is the standardization element in the coordination mix. No additional messages are necessary in case there are no disturbances: the error signal "e" = 0 in Figure 7.8. We may thus conclude that messages 5. - 9. (see Annex 7.I) are feedback or error handling messages. The emergence of the need for these messages is discussed next, after we present the IR state for the Level B design.

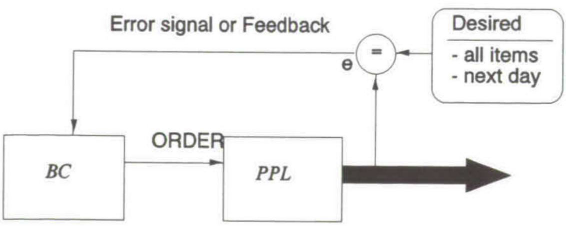

Figure 7.8 - The feedback loop due to disturbances ("e" unequal to 0).

The IR state diagram for this Level B design is depicted in Figure 7.9. Compared to the actual IR state of the delivery process given in Figure 7.6, which represents the total design (Level B as well as Level C) the attributes 'y=deliverability' and 'z=delivery status' are missing. These attributes result from disturbances as will be discussed next, and therefore do not appear in the Level B design, but are added to it by the designer as he progresses on to the Level C design of the VAP.

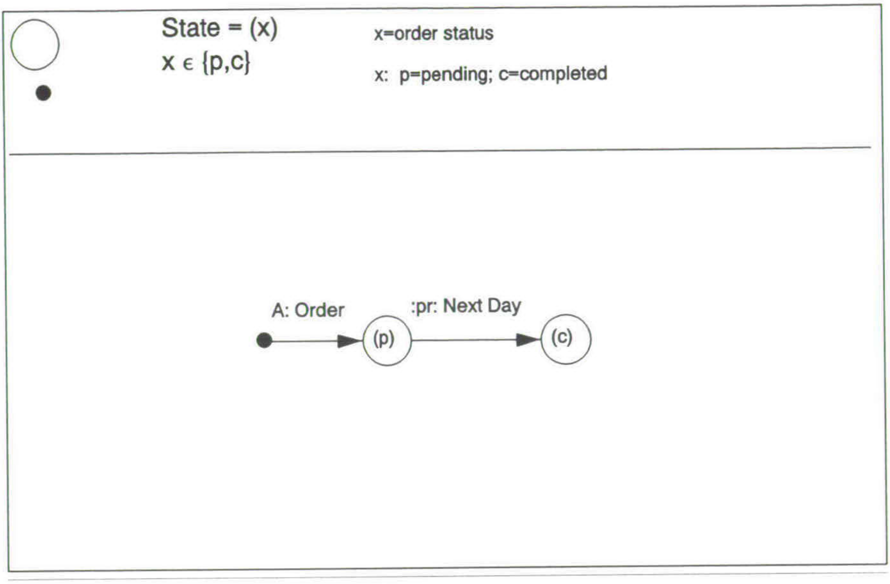

Figure 7.9 - The Level B IR state diagram for the delivery process (compare with Figure 7.6)

Level C design

In the previous section the Level B design pertaining to the disturbance free situation was discussed. Recognizing that there are disturbances in any real life logistical process, introduced the need for feedback. The most common form of a feedback message is a report.

Because of the disturbances in the Beauty-PPL process II the need for feedback messages 5. - 9. emerged (see the Message Table in Annex 7.I). These disturbances are:

- PPL does not have sufficient capacity to deliver the next day;
- There are inconsistencies between the administrative inventories of PPL and Beauty;
- There are inconsistencies between the administrative and physical inventories at PPL;
- There are inconsistencies in the article bases of PPL and Beauty.

The resulting messages are given in Table 7.5 along with their Message Table (Annex 7.I) reference number between parentheses.

Table 7.5 - Disturbances and feedback in the design

Disturbance	Feedback Message	Comment
Capacity problem	• REPORT (5) • LIST-PENDING-ORDERS (9)	Time of delivery of the order. This is feedback on not delivering an order at all.
Admin.Inv. Inconsistencies	• NON-DELIVERABLE-ARTICLES (7)	Time critical feedback message which will cause the blocking of items from sales.
PPL Inv. Inconsistencies	• PICKING-DIFFERENCES (8) • REPORT (5)	Time critical (see above). Contains the actual number delivered, which will differ in case of physical inventory shortage.
Article Base Inconsistencies	• ERROR-LIST (6)	Because of the update frequency of one week. If this occurs PPL has to update the article base.

7.2.4 Theoretical construct analysis

The coordination mechanisms

The *type* of the coordination mechanism is the standardization of process type: the design phase has resulted in a Manual containing the blueprint that governs the interaction between both OUs. As we have seen in the previous section some disturbances are anticipated and are handled in a standardized way. Each boundary crossing process has its own coordination mechanism, of which the decision making- and the communicating aspect are discussed next.

The replenishment process

Design coordination in the form of agreements with respect to the load in this process, i.e. two or three trucks per day, assure that PPL has the capacity available to meet the requirements of performing the internal order which is the SHIPPING_LIST. The SHIPPING_LIST is an order from Beauty to PPL to accept and store a shipment of finished product into the warehouse. Beauty determines on the basis of its own information, e.g. the finished product inventory, and on the basis of coupling information about the LC inventory which pallets will be shipped to PPL. The decision rules they apply therein are not shared with PPL, but these are not relevant to PPL anyhow. This unilateral determination of an order by Beauty at first sight points in the direction of no operational coordination taking place in the replenishment process. Closer examination reveals that operational coordination is present. The sending of the SHIPPING_LIST in advance of the actual truck arrival at the LC, is actually a pre-order, which allows for the concurrency in this process. The real order is the truck with the original SHIPPING_LIST the trucker has.

The order delivery process

Beauty accepts customer orders and subsequently relays them to PPL on the basis of coupling information about the inventory level at PPL. Part of the decision rule applied in this process is thus shared by both OUs: only items for which PPL has inventory can be relayed. The information on which Beauty bases its decision is also shared: weekly updates of PPL's inventory level status information.

The standardization of process type of coordination is reflected in the procedure which determines the time attribute, t, of the internal order:

> "48 hrs for normal orders, 24 hrs for rush orders".

In this VAP, the superior calculates his own action on the basis of the variable shared, which is the inventory level at PPL (Admin_Inv_level). If this variable is too small for a certain article, Beauty will not send the orderline containing that article to PPL.

Intrinsic Uncertainty

This process is characterized by demand uncertainty: Beauty has no idea when customers will place their orders. The production process of Beauty and hence its suppliers and supply uncertainty are not included in our study. Notice that this does not influence the VAP at all: it is Beauty's responsibility that there is enough finished product inventory. PPL ought not be affected by Beauty's out of stocks.

Task Uncertainty

Part of the demand uncertainty is transferred on to PPL, where it effects the capacity problem. PPL, being a Service Logistics System has no material problem. By building slack into the process in the form of time, PPL can resolve this problem by hiring extra picking personnel. This time slack is due to the fact that PPL receives the order at the end of day 1, and only has to start working on it on day 2 in the morning. In the evening of day 1, PPL has time to assess its workload for the next day and determine whether to hire extra capacity. This is an illustration of the Law of Possible Variety: the ability to hire extra capacity denotes a higher $Var(M_{PPL})$ enabling PPL to cope with more variety in the environment and the GAS, i.e. the ability to handle fluctuations in customer demand and (physical) work load. That more $Var(M_i)$ may benefit from more coordination, in this case the advance information, was discussed in section 4.5 and was illustrated by Figure 4.25.

GAS Uncertainty

GAS uncertainty in PPL results as a consequence of unreported damaging of goods, pilferage, and picking mistakes. The latter source of GAS uncertainty is substantial since the packed products of Beauty all look alike. In Figure 7.5 the mismatch between the administrative inventory level and the actual inventory level at PPL is depicted (mismatch a.).

IAS Uncertainty
In chapter four we dismissed IAS uncertainty from our analysis because it is often annihilated by EDI. In practice things are not that simple. IAS uncertainty in this example is present because fax information of the SHIPPING_LIST is entered manually (EDI would eliminate this source of IAS uncertainty). So is the picking list at the warehouse. Another source of IAS uncertainty arises, strangely enough, because of EDI: people at different ends of the OU sometimes bypass the formal communication channel and fail to make the relevant alterations in their respective information systems. This is of course a consequence of bad procedure, but basically caused by the notion introduced in chapter six of interference between communication channels.

Boundary Uncertainty
The boundary uncertainty is caused by the low synchronization frequency of the inventory level at the LC and the low synchronization frequency of the customer-, article-, and consumer unit data bases (the standing data or process model data).

7.2.5 Theory based areas for redesign

From the theory of logistics coordination areas of search for EDI induced redesign, which are summarized in Table 4.4, were derived. Of these different levels of redesign we will next discuss the reduction of BU, the reduction of DoF, and the increase of $Var(M_i)$.

Reduction of Boundary Uncertainty
In Figure 7.5 the main consequence of BU, the mismatch between the administrative inventory levels (mismatch b.) can be resolved by increasing the update frequency between the two linked databases. The same holds for reducing the BU as a consequence of desynchronized standing data, i.e. the customer-, article, and consumer unit data bases. A fixed frequency which is higher than once a week, or an event driven update approach could be adopted. One solution to the problem is increasing the frequency of the LC-inv-level message from once a week to e.g. once a day, or even once an hour. The higher the frequency of the LC-inv-message the more the solution will reflect the ideal situation of a shared database for that particular variable. If a shared database were implemented, and hence no difference in perception of the inventory level could occur, the IR state diagram given in Figure 7.10 would result.

Reduction of the Degree of Freedom and increasing $Var(M_i)$
In process II, the delivery process, the DoF could be lowered by letting PPL deliver on day 2 orders that are received on day 1. Orders placed before for instance 15:00 hours will then be picked the same day and delivered the next day.

First of all this redesign requires a reduction of boundary uncertainty: instead of sending all orders in a single batch at 15:00 hrs, PPL should have access to Beauty's goal information on a more continuous basis, e.g. every half an hour.

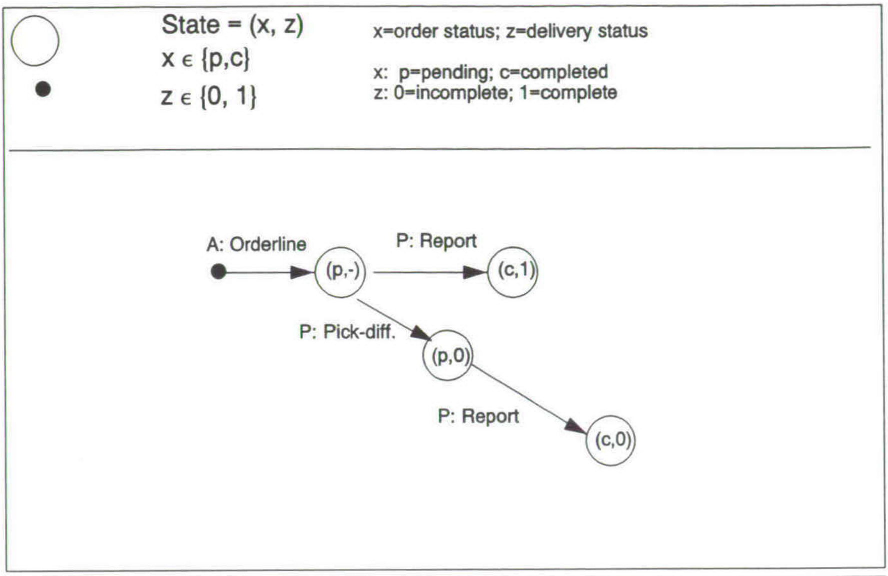

Figure 7.10 - The IR state in case of a shared database

In addition this reduction in DoF requires two types of responses if delivery reliability is to be maintained (see Figure 7.11):

(a) either counter DoF measures are taken, i.e. the DoF is increased again, or
(b) $Var(M_i)$ increasing measures are taken in combination with improved coordination.

An example of the first strategy (a) is that PPL takes on more slack capacity (personnel) in order to cope with variances in load. An example of the second strategy (b) is that PPL finds an outsourcing bureau that can deliver extra capacity on a very short notice. The action "delivery two order pickers within an hour" increases the variety in (control) action of PPL. This latter option requires more coordination between Beauty and PPL than the slack increase option. PPL will in order to hire the extra capacity benefit from pre-information (=boundary uncertainty reduction = coordination) from Beauty on expected increases in sales volumes, e.g. as a consequence of promotional activities. In the slack option the capacity is already available and peaks in demand can (almost) always be met. Both strategies are depicted in terms of the Var(M)-DoF grid in Figure 7.11.

For the performance this means that the lead time is reduced, the delivery reliability maintained, while the costs are increased. Either because of the slack capacity (strategy (a)) or because of the fact that an outsourcing bureau that can deliver on such a short notice will probably be more expensive than one with a longer reply time (strategy (b)). The better the coordination between Beauty and PPL, the lesser the need for short term ordering of capacity, the better the overall performance. Hence, better coordination may reduce the cost of extra Var(M). VAPs and EDI are means of performing this coordination at relatively low cost.

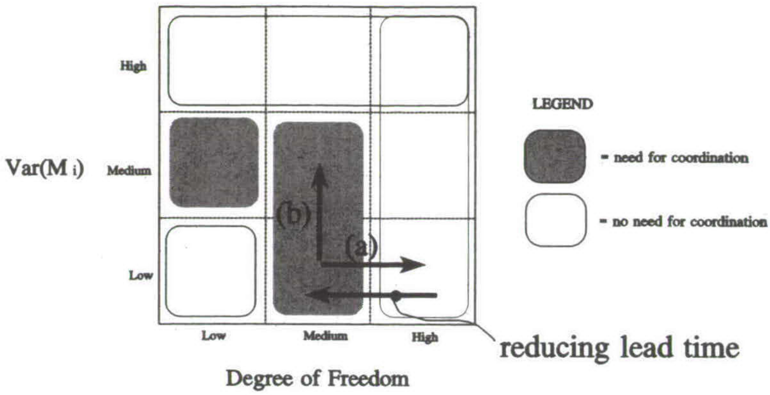

Figure 7.11 - Redesign strategies in terms of the Var(M)-DoF grid

7.3 A case study in transport

This case is the VAP between the liner Sea-Land and the stevedore ECT in the Rotterdam Harbour governed by a long term contract of 20 years. Together they have designed a container terminal operated by the stevedore and fully dedicated to the liner. Over 50 EDI messages have been designed to jointly control the goods flow on the terminal. This case differs from the previously described one in a number of respects. First of all, the research was conducted during the design phase of the VAP. While it has not been stated as a research problem, some description of the design process will be provided. Secondly, this VAP is more intense, i.e. the processes in the OUs are more tightly coupled, than in the previous one. Both OUs are designed from scratch (a greenfield approach). The heavy investments by both parties may account for the longer duration of the VAP contract in this case as opposed to the previous case.

7.3.1. Introduction

The operational units (OUs) of two organizations, the liner Sea-Land (SLD) and the stevedoring company ECT, that are joined in a VAP are described. The OUs of interest are those units of the organizations that are responsible for the operations at the Delta-2 container terminal. The Delta-2 terminal is a new ECT terminal dedicated to their customer SLD. From here on these OUs are referred to as SLD and ECT.

The Delta-2 terminal is a highly automated container terminal. The terminal was officially opened on June 25th, 1993. It uses automated guided vehicles (AGVs) for carrying containers between the stack[7] and the vessels. Within the stack containers are stored and retrieved by means of (the world's first, see Munford 1989) automated stacking cranes (ASCs).

In this study, as opposed to the previously described case study, we were involved in the design phase. We thus witnessed the design coordination, i.e. meetings among representatives of both organizations. Several sub design teams had been formed dealing with specific subsystems of the overall design. We participated in two design teams, one dealing with the specification of operational procedures and aspects of information systems, the other with the specification of EDI messages. The former team was also the forum in which proposals from other design teams were approved. During the design, all proposed designs were checked with the personnel from the operational departments of the (old) existing terminal who would be working on the new terminal. This was done not only to validate the designs, but also to increase user acceptance and reduce resistance to change (see our recommendation on this point in section 3.1).

We will refrain from discussing technical details, but one point is worth mentioning. The OUs have decided to use separate, but linked databases. As a consequence a lot of EDI messages[8] and procedures have been defined in order to keep databases synchronized. The rationale behind this choice is a very logical one. Both OUs have to deal with more parties than just each other: ECT is a service provider and wishes to reuse the current system for every other customer with which they form a VAP, instead of going through the (painful) process of defining a shared database over and over again. SLD has specific requirements with respect to its database that have nothing to do with the operations on the delta-2 terminal. The drawback of linked databases is that the OUs have to go to the tedious and crucial process of keeping the databases synchronized.

The terminal is entirely new, meaning that the design includes everything from buildings, infrastructure, the development of new equipment (AGVs, Reefer cars, ASCs), information systems, procedures, up to the organization structure and error handling procedures. Strictly speaking this is not a case of re-engineering for there are no existing processes; instead the term engineering is applicable.

In the remainder of this section we will give a partial description of the operational processes on the terminal (section 7.3.2), followed by an assessment of the practical applicability of our theoretical concepts (section 7.3.3). In section 7.3.4 some of our practical guidelines and instruments are discussed. The section is concluded with an evaluation of the case study.

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[7] The stack is the storage point for containers.

[8] About 35 % of all messages defined for the two most important processes, road and stowage, are pure status messages used to keep databases synchronized. The other messages which are orders and reports also contain elements for conveying status information, making the provisions for status data exchange even higher.

7.3.2 Description

On the delta-2 terminal ECT handles SLD vessels. This handling includes loading and discharging of vessels, storing and delivering containers from and to trucks arriving by road, and transporting containers to and from other terminals: the barge and rail terminal and the existing delta-1 terminal. The handling also includes transporting containers to and from specific SLD areas on the terminal. Before describing the processes and subprocesses, the physical infrastructure and the possible container flows are given.

The physical infrastructure

The layout of the terminal and those parts of its environment to and from which containers flow are depicted schematically in Figure 7.12. Some of these areas belong to the physical infrastructure of SLD, while the majority of the areas are part of the ECT physical infrastructure. So although the locations are meshed into one diagram, they do belong to different OUs, the major implication of which is that a container is out of view of one organization when in the other's physical infrastructure: status and steering signals from and to the GAS are confined within the boundaries of one OU. It is not necessary for our purposes to discuss all of the areas of the physical infrastructure in detail. The gate is the entrance for trucks to the terminal, and is a SLD area. SLD knows which trucks, delivering and/or picking up a container, are allowed on the terminal. The stacking area (ASC) is storage area for containers. How and where containers are stacked is ECT's responsibility. Delta-1 is an existing multi-user terminal of ECT, while the Barge- and Rail Container (BRC) terminal is also operated by ECT for loading and unloading of trains and barges.

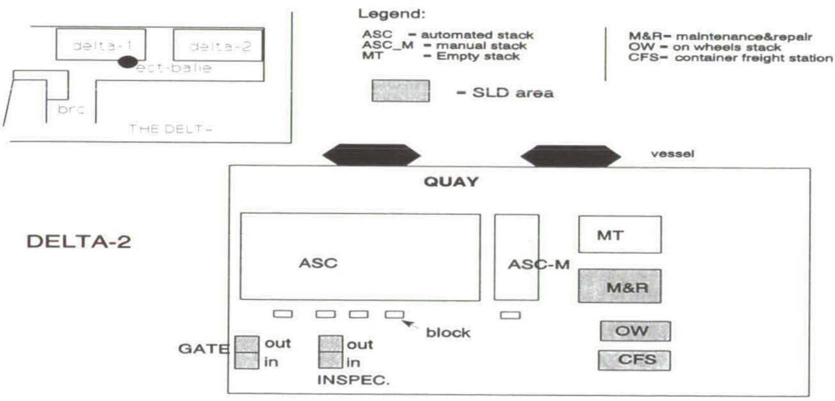

Figure 7.12 - The Physical Infrastructure of the Delta-2 terminal

The container flows

There are five major container flows on the terminal: four between the terminal and its environment and one within the terminal (see Figure 7.13). This figure merely represents the physical flows. The accompanying information flows are far more complicated and different per flow and per direction in the flow.

Containers arriving by sea can leave the terminal by sea, road, barge or rail. Containers destined for a vessel (sea) can enter the terminal by barge, rail, road, or sea. The barge and rail containers are handled by a separate ECT OU called the 'barge and rail container terminal' (BRC). There is also a container flow between the delta-1 and the delta-2 terminal. The container flow within the terminal, flow (4), represents moves of containers between SLD and ECT areas. Flows initiated by ECT and carried out within their own areas (e.g. restacking, Du: "interne verkassingen") are not included in this flow. The messages and information needed to plan, initiate and control these flows, in other words the processes that accomplish these flows are described in the next section.

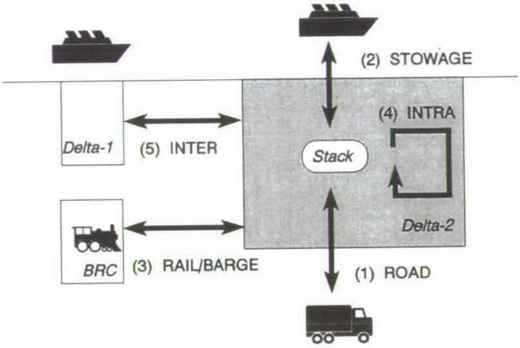

Figure 7.13 - The scenarios at the SLD-ECT delta terminal

The logistical process on the Delta terminal can be divided into several scenarios (see Figure 7.13) which are disjunct. "Disjunct" means that the timing of exchanges (messages or goods) between both organizations in one scenarios are not contingent on exchanges in another
scenario. This allows us to describe these scenario's separately. The scenarios are: stowage, barge & rail, road, intra and inter.

Stowage refers to the waterside operation of the terminal. Loading and discharging of vessels and all messages that accompany this operation are part of this scenario. In the barge and rail scenario the exchanges with the BRC terminal are dealt with. The handling of containers entering or leaving the terminal by road on trucks is embedded in the road scenario. Intra refers to the movement of containers and the accompanying messages on the yard, while inter deals with the same for the flow of containers to and from the (existing) Delta-1 terminal.

These flows are decoupled through the ASC, which is a process decoupling point (see section 3.3). For instance a discharged container (flow 2 - in) is always transported by an AGV (automatic guided vehicle) to the stack, from which point it can be delivered to a truck (flow 1 - out). The same is true for incoming containers by road: it is not possible for a truck to bypass the stack and drive to the crane to deliver a container directly to the vessel.

The process description

In order to avoid confusion some elucidation of the concept "process" is appropriate. Organizations are modeled as communicating systems (OUs). The description of the tasks and precedence relations per OU is called the process description. So there is a SLD process description and an ECT process description, each description being confined to its respective OU. A logistical process however is not confined within the boundaries of a single OU, but boundary crossing: the "task path" traversed lies in more than one OU. There may be several processes in a set of OUs: these processes are loosely coupled in "generic" (thus not necessarily "customer order") decoupling points.

In this case these processes are coupled to one of the flows of Figure 7.13. These processes are not confined within one organization but involve both the SLD and ECT OU. The development of the messages that are to be exchanged can be described per process (or "scenario"):

- flow (1): road,
- flow (2): stowage,
- flow (3): barge and rail,
- flow (4): intra,
- flow (5): inter.

In the remainder we will restrict ourselves to the road and stowage processes.

Orders and logistical processes

Above the physical infrastructure and the possible container flows are described. This is description of the GAS. The flow of containers is controlled through steering signals from the IAS. ECT is responsible for most (except at the gate) of the steering signals to the GAS. However, SLD is the one who determines most of what ECT does by sending orders to ECT.

All logistical processes are triggered by orders. This is true for SLD as well as for ECT. All orders to ECT emanate from SLD (see Figure 7.14). SLD's orders emanate from the environment of the VAP. There are four types of incoming orders (S_i-orders) for SLD. From the Sea-Land corporate information system:

(1) orders to handle vessels calling on Rotterdam;
(2) orders to discharge, store, and load relay containers;[9]
(3) orders to discharge and to deliver (to the road, rail, barge) containers destined for Rotterdam.

From customers and/or Sea-Land's booking office (=liner agent):

(4) bookings for space on a vessel (seabound containers).

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[9] In the design of the delta-2 terminal specific consideration was made for SLD's *Majority from Sea to Sea* (MSS) strategy. Operations in Rotterdam are predominantly water-to-water transshipment (see also Munford 1989).

Notice that the booking office and the corporate information system (physically located in the US) are viewed as separate actors or OUs, and not part of what the OU we call SLD in this description.

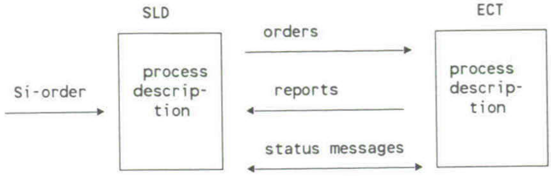

Figure 7.14 - The processes and orderflows

Focus

Interesting for our research is the existence of a clearly delineated logistics process, which is jointly controlled by two organizations: the stevedore (ECT) and the liner (Sea-Land). There are contingencies on the operations of other organizations (e.g. customs, partner liner organizations, the barge and rail terminal (BRC), Delta-1), but the analysis of this case focuses on the inter organizational relationship (IR) between Sea-Land and ECT. It suffices for the case study objectives to limit the study to the subprocesses regarding the road and the sea. We will next give a description of the road and stowage scenarios.

Description of the road scenario

Trucks enter the terminal either to deliver one or more containers, pick up one or more containers, or a combination of both. The operator of this container can be SLD or any other liner who has a vessel sharing agreement with SLD and is referred to as a partner. The 'paperwork' on partner containers is handled by ECT at the ECT desk, which is located outside the terminal. SLD containers are handled administratively at the gate of the terminal, by SLD personnel. As mentioned above, we will not further consider partner operated containers.

Truckers are issued a keycard which is used for identification purposes throughout their trip on the yard. From the gate the trucker who has containers to deliver drives to inspection. At inspection the physical condition of a container is assessed, and the information on the container, e.g. container number, seal number, are visually checked and updated if necessary. (In case of damage a trucker is directed to the maintenance and repair (M&R) area on the terminal. We will further ignore this flow in our description.) From inspection the trucker is routed to one of the blocks. On the way out the trucker passes inspection (if he has an outbound container), and from there to the gate out where he hands in his keycard.

The officer at the gate of the terminal collects from the trucker the information necessary to, among others, order service from ECT, either for a pick-up or for a delivery (the SEABAL message). ECT assigns on the basis of some optimization routine an exchange-block-number to the trucker and sends a message containing this number (ROUTEP message) to SLD. This exchange-block-number is conveyed to the trucker while he is in the inspection lane (a SLD area; see Figure 7.12). Because of the time-criticality, the trucker cannot proceed without the exchange-block-number, EDI is a prerequisite for this way of working.

Administrative tasks are only considered here if they interact with the logistical process. That is when they affect (hamper) the flow of the goods. They could as such be looked upon as being part of the logistical process. These tasks are performed at the gate and are contained in the 'cargo control function' of SLD information system (RTS). Cargo control among other things checks the connection of containers to bookings and the accompanying transport documents. Containers are not allowed on the terminal unless the booking number specified in the documents the trucker carries with him exists. Similarly, containers are not allowed to leave the terminal unless the container has been 'released' by the agent, e.g. after the freight has been paid.

The layered organizational model. For the road scenario the tasks in the *coordination* layer of SLD pertain to the assembling/sending and receiving/processing of messages to and from ECT. *Physical or logistical* tasks within the SLD part of the road scenario are the reception of a truck at the gate, including the collection of relevant information from the trucker. Inspection of containers (both incoming and outgoing ones) is another logistical task in the SLD process. The logistical tasks performed by ECT are the storage and retrieval of containers in/from the stack, which are reported to SLD by means of status messages (the COARRI and CODEPA messages). *Internal control* tasks are concerned with the processing of the collected information, and the determination of the routing on the yard from gate to either inspection, the bypass lane, or the SLD trouble counter. Keeping track of issued keycards and the termination of trips on the yard are tasks within this layer.

Description of the stowage scenario

The stowage scenario entails the loading and discharging of vessels at the delta terminal. SLD informs ECT by means of a call information message (CALINF) of the expected arrival of vessels 48 hours in advance. More detailed information on the number of container moves per part (hatch or deck) of the vessel are sent at least six hours before expected vessel arrival (by means of the CALIHD message). The call information messages (CALINF and CALIHD) are plans that give ECT a picture of the expected load. The actual moving of containers is initiated by orders from SLD.

Orders for discharging and loading of containers are given by means of the container pre-arrival (COPRAR) and pre-departure messages (COPRDP). ECT reports these moves back by means of container arrival (COARRI) and container departure (CODEPA) messages.

The location of containers on a configured vessel are sent to ECT in the bayplan (BAPLIE message). ECT has coupling information on the configurations of configured SLD vessels. This allows them to interpret the bayplan.

ECT sends a workplan just before it starts working on a vessel to SLD containing the planning for a particular vessel. This information is of interest to SLD because the internal control task stowage (planning of which containers are positioned where on a vessel) can proceed concurrently to the physical stowage of the vessel.

It is possible that a container that should not have been discharged is discharged by accident. This is reported by means of an container overlanded (COOVLA) message. The opposite can also occur, a container which should have been discharged was not, resulting a container shortlanded (COSHLA) message. Both messages are of course sent from ECT to SLD.

7.3.3. Theoretical construct analysis

Several concepts from our theory (chapter four) are discussed. First the notion of Value Adding Partnership (VAP) as presented in chapter three is elaborated upon.

Value adding partnership
The agreement between Sea-Land and ECT is clearly a VAP: two organizations working closely together to jointly control the goods flow. The long term contract governing this IR has a time span of 20 years. Within this contract thousands of transactions, e.g. store container in the stack, are executed daily (recall Figure 3.7). In all these transactions, Sea-Land is the superior and ECT the subordinate, i.e. orders flow from SLD to ECT. In the opposite direction, from ECT to SLD flows mostly status information and reports.

Operational versus design coordination
The coordination between the SLD and ECT is primarily one of standardization: all interactions between the processes are handled in a predetermined standardized manner, jointly developed and agreed upon by both organizations. These interactions were jointly determined during the design phase of the VAP, i.e. the time between signing of the contract and the actual start of operations on the terminal took over four years. In the design phase representatives of both organizations were combined into project teams to jointly design layout, buildings, equipment, procedures, and communications. The teams were not only coordinating, but also cooperating, i.e. producing a joint output. Coordination was not only logistics coordination, i.e. other variables than those pertaining to time (T), place (X), and physical object specification (PO) were adjusted. E.g. the exact location and dimension of buildings were determined through mutual adjustment. All adjusting of decision performed in the design phase is called design coordination. When we go to the terminal today, in its operational phase, we can observe operational coordination taking place.

The decision making aspect of the coordination mechanisms is embedded in the timing scenarios for messages. The communicating aspect refers to all pre-information, planning and status messages.

Intrinsic Uncertainty
In the road scenario SLD has intrinsic uncertainty with respect to the arrival of seabound containers, i.e. in orders from the booking office. SLD knows that certain containers will

arrive, but it does not know when they will arrive exactly (they may arrive shortly before vessel departure, the late arrivals). This IU also affects the stowage task of SLD, because an order for loading of a container must be given to ECT two hours before its actual loading. In addition ECT will only accept this order if the container is on the yard, i.e. in the stack. This complicates the stowage task and results in less than optimal stowplans: containers that arrive halfway along the stowing of the vessel, must be placed in slots that are not the optimal ones given the containers' characteristics. Further uncertainty in the number of trucks calling affects the staffing of the gate (= a capacity problem). Notice that there is no intrinsic uncertainty in the arrival of containers in the stowage process. This information is known by SLD at the moment a vessel departs from its port of departure, which is days/weeks in advance of arrival in Rotterdam.

GAS uncertainty
Uncertainty in the GAS is present in the form of mistakes made by ECT and errors in the status of containers, e.g. a container appears to be damaged, or is stored on the vessel in a different location than expected (error made by the stevedore in the previous port). This GAS uncertainty lowers the performance in terms of vessel and truck turn-around times.

The required performance and Task Uncertainty
The objective for the VAP is to have a truck turn-around time which is as low as possible (less than 45 minutes). This is the time a truck spends on the terminal. Further the handling time of vessels should be as short as possible. In the road scenario this means that ECT must be swift on delivery of containers to a block, and fast on pick up: a trucker should not wait long to deliver or pick up a container at the exchange blocks. This is accomplished by having SLD send information on a trip to ECT (the SEABAL message), instead of randomly directing the trucker to the exchange blocks. ECT uses this information to calculate an exchange block that will, given the mission of truck, result in the lowest truck turn-around time. The exchange-block-number is communicated back to SLD through the route plan (ROUTEP) message. As ECT knows that a truck is on its way, and where the truck will call on ECT, ECT can make the equipment available to serve that truck. Thus, high required performance increases the need to know, i.e. is accompanied by high task uncertainty.[10] The task uncertainty is matched partly by letting ECT determine the action of SLD's trucker.

Information diamond and Boundary uncertainty
The status of SLD is largely determined by the status of ECT. The goal information of ECT is derived from SLD's goal information, i.e. bookings for vessels, and bayplans for incoming vessels containing container destined for Rotterdam (either as a transit port or final destination port). Since these links of the information diamond (see Figure 4.24) are almost fully supported (e.g. all status changes are reported every 10 minutes to SLD, information on orders is exchanged as early as useful to ECT) the residual of boundary uncertainty (BU) in this VAP is very low. We therefore conclude that the coordination between SLD and ECT is almost optimal: as if they were one integrated organization.

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[10] Recall that task Uncertainty is a function of the required performance, internal design and intrinsic uncertainty (see chapter four).

Degree of Freedom
The DoF is low: every arrival of a truck or a vessel at SLD results immediately in an action to be taken by ECT. This is possible because SLD gives all available information on orders as early as possible, and because procedures in the design phase are agreed that are feasible. EDI allows for reducing the DoF in the stowage scenario: while ECT is stowing a certain hatch of the vessel, SLD can continue stowplanning for another part of the vessel. The DoF is low because there are more actions, i.e. stow(planning) several hatches as opposed to stow(planning) one vessel, and the time lapse between actions is shorter. Electronic communication and processing of (part of) the stowplan enables this low DoF.

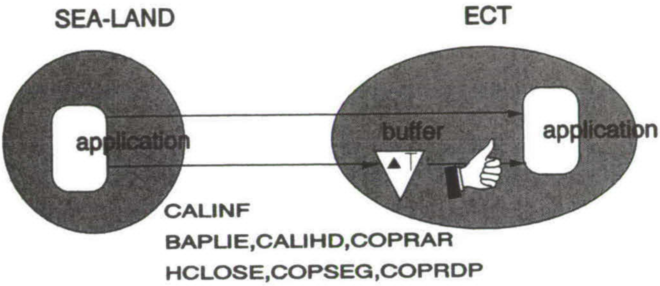
Variety (M)
SLD provides ECT with information about the expected destination of a container. ECT uses this information to determine the location of a container in the stack: e.g. if a container is ultimately destined to leave Rotterdam via BRC, then a location near BRC is sought to store the container. This is an example how variety in the IAS can create variety in the GAS. The ability of ECT to control the GAS with such useful precision is a reflection of high Var(M).

7.3.4 Illustration of design support guidelines

Omission in the IR state diagram
In this paragraph an initial flaw in the business communication protocol will be described. This is an example of how organizations failed to adhere to the IR state guideline. The result of this flaw, the unjust rejection of messages by ECT, would have resulted in the desynchronization of the linked databases (this error was detected in the design phase). A number of messages are read into the ECT application hours after they have been sent by SLD (see Figure 7.15). ECT's motivation for doing this is twofold:
- space in the database (performance);
- some leeway for the operations planner.

This causes problems because SLD assumes that ECT has taken notice of a certain event, while ECT has not: the message is still 'unread' in the buffer. We will sketch two situations in which the lack of similarity in perception of the IR state causes problems.
Situation 1. SLD may wish to send a container information update (COINUP message) on a container for which they have a discharge order (COPRAR) outstanding, i.e. a new container coming in from sea. As they assume the container is known to ECT, they send the COINUP which gets rejected because ECT does not know the container. (Mind you that SLD has no way of knowing when messages are retrieved from the buffer by the planner).

Situation 2. SLD may also wish to send a COINUP for which they have a loading order (COPRDP message) outstanding. As this container is on the yard ECT knows the container, accepts the message, and updates the database. After some time the COPRDP is pulled from the buffer and the 'old' data in the COPRDP overwrites the COINUP information, which was the latest information sent by SLD. This is a serious problem because it is 'silent': it goes unnoticed to both SLD and ECT, and differing databases result.



7.15 - Messages that are buffered by ECT and retrieved manually

The problems are caused by differing perceptions of the state of conversation (see chapter six). If the IR state communication design tool is used from the beginning when designing the communications protocols, omission like the ones described will be avoided.

The communication channel

EDI is a formal means of communication which feeds directly into the automated application at the end of the line. The danger is that there is no more room for informal communication. Compared to the old terminal, SLD can at the delta-2 terminal formally send the order to load a container on a vessel later, i.e. two hours before ECT starts working on the hatch where the container will be stowed. However, informally SLD could in the old situation have a container loaded within 5 minutes. This would be done for 'late arrivals' (by road) that must leave on a particular vessel. In the new situation the information systems of ECT are largely automated and do not accept orders that fall outside the procedure. The manual intervention needed is much more difficult since the system needs to be bypassed. So while formally the flexibility has been improved, i.e. an order can be sent later, it has become more difficult to resolve interference between the automated formal channel and the informal channel.

7.3.5 Evaluation

This case is an ideal example of a dyadical VAP. Although ECT has many more customers the plant or OU described is fully dedicated to the customer SLD. Operations have been jointly designed to fulfil each other's needs and requirements, from physical infrastructure, to equipment, and operational procedures (including messages and scenarios for their exchange). Because this VAP has been designed 'from scratch' this is really a case of design and not redesign. EDI has been a part from the design from the beginning and therefore 'EDI induced redesign opportunities' were not found in this case. EDI is a prerequisite for the way of working adopted by SLD and ECT. Further, typical redesign 'traps' such as sticking to old ways of working and thinking have largely been avoided. Design in this case was more of what Gasparski (1984) calls the 'design approach' than of the 'improvement' approach.

We were able to operationalize our concepts, and apply the reasoning laid down in chapter four. The relevance of both the IR state diagram and the notion of formal and informal communications channels has been illustrated in this case. Finally, this case description conveys only a small part of the VAP design, both the verb and the noun. As an exploratory case the abundance of data and impressions is ideal, as an illustrative case, the abundance is a trap. The challenge for the case researcher who uses a single case for both purposes is to find the right moment to move from exploration to illustration.

Though an ideal case of a *dyadical* VAP, the situation is not ideal from the perspective of an entire logistics chain. Having managed the uncertainty amongst themselves within the dyad, i.e. between SLD and ECT, the organizations are now faced with the uncertainty outside the dyad. Long waiting times of transporters at the gate (see Jol 1993) as a consequence of lack of coordination emphasize the well known point of suboptimization. Does this render a study of dyadical partnerships and hence our theory of coordination obsolete? No it does not, for two reasons. First of all, having three uncoordinated parts in a chain is better than having four uncoordinated parts in a chain. Secondly, we expect that having several bilateral partnerships is practically more feasible than having one multi-lateral partnership. It is very likely that chains will be coordinated in a pairwise fashion. We do recommend, however, further research on coordination in VAPs of more than two organizations.

7.4 A case study in sourcing and distribution

This section reports on the application of our design knowledge during a consultancy engagement. Opposed to the previous two case studies in which the focus was explorative and illustrative the focus in the present case study is more applicative. Starting with the client's perceived need for advise, an analysis is performed and a target for the new design is set. Through application of the line of reasoning embedded in the coordination theory, the methodology presented in Figure 6.10 is traversed up till the third phase. The output of this process are the basic designs of two VAPs that the client should pursue, i.e. a vision. As is often the case in an consultancy engagement the client, particularly at this stage of design, is a *single* organization. In our advise to form VAPs with manufacturers and transporters we have applied general knowledge concerning the operations of these types of organizations.

7.4.1 Description

The client, Vegpack[11], is an organization responsible for the design and availability of packages in the vegetable and fruit sector (V&F-sector) in the Netherlands. In the Netherlands there are approximately 2500 producers of V&F. The produce is sold through about 20 auctions spread around the country (Boesten 1995). Produce is packed either in a standardized package or in a specialized package carrying a brand name, which is either a producer's, a buyer's, or a retailer's brand. With buyers the intermediate traders are meant.

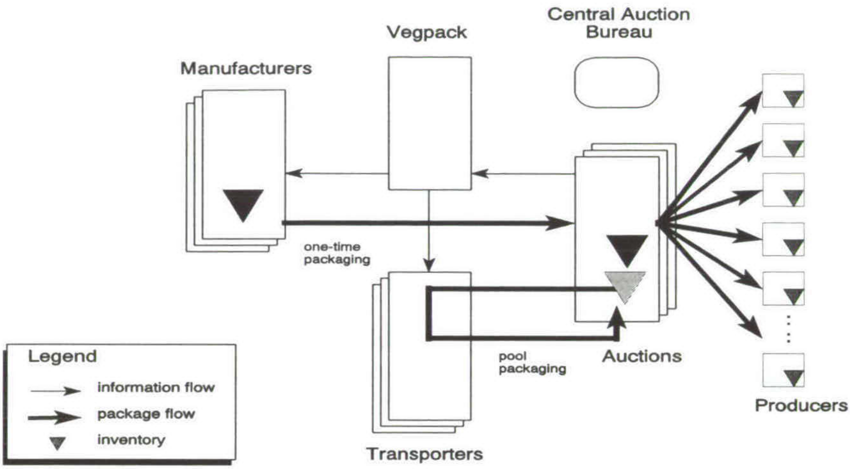


Figure 7.16 - Vegpack at the centre of packaging flows in the V&F sector

The packaging used is either one-time carton packaging or reusable plastic or wooden pool packaging. For the one-time packaging Vegpack is responsible for the production and availability during the season. Reusable packaging must be made available at the different auctions throughout the season. As the auctions have different main products, each with their own seasonal pattern, and buyers have preferences for returning reusable packaging to certain auctions, the allocation and relocation of reusable packaging is a critical and time consuming task. Auctions are responsible for ordering one-time packaging, i.e. they are responsible for inventory control. Vegpack is responsible for the availability of pool packaging (inventory control) at the auctions. Packaging is delivered to the auctions where it is picked up by the individual producers.

The turbulence in Vegpack's environment urged them to acquire consultancy in setting up an inventory management system. Such a systems was perceived as an enabler for coping

[11] Although permission has been granted for publication of this case, a fake name is used to refer to the organization involved.

with the (future) challenges confronting them:

- an increase in package variety due to increasing need of producers and buyers of fruit and vegetables to distinguish themselves from others;
- an increasing frequency of switching between packages (contracting life cycles);
- increasing competition from foreign producers of vegetables and fruit forcing down the prices of produce and putting pressure on the relative cost of the packaging;
- increasing environmental pressure affecting the cost of transport, thus increasing the need for efficient reallocations of pool packaging;
- increasing concentration at the side of their customers, the auctions.

We found the latter development especially threatening to Vegpack's added value, which lies mostly in their economies of scale. For Vegpack to remain valuable implies developing highly specialized core competencies, and be outstanding at them.

In workshops with managers from Vegpack as well as some of their major customers (the auctions), two major inventory related problems were identified:

(1) the high volume of obsolete stocks of one-time packaging;
(2) the insufficient inventory information.

Our analysis

After an initial scoping of the processes of Vegpack it became apparent that automating the current process of inventory management was a matter of what Hammer (1990) calls 'paving cowpaths'. Information was only part of the problem, and it was felt that a broader perspective should be adopted. Processes and inter organizational relationships should be audited and possibly redesigned. Application of the method outlined in chapter six results in the following analysis and subsequent recommendations for redesign.

7.4.2 Phase I - Set target

The first phase sets the targets for the remainder of the project. Given the situational analysis the redesign effort must aim to achieve the following improvements in the performance of Vegpack.

- Reduce excess inventory at the end of the seasons; especially with the increasing variety in brands the risk of obsolescence of stock has been greatly increased.
- Reduce inventory throughout the supply chain, at the manufacturers as well as the auctions.
- Increase transport and reallocation efficiency.
- Improve supply chain responsiveness; in a volatile environment where the use of a certain type of packaging is difficult to predict the ability to react quickly is a must.
- Improve customer service, i.e. maintain 100% reliability, reduce order cycle time.

At this point it is not possible to specify the target performance between the different organizations. This depends on the redesigns proposed. These inter organizational performance measures are very important in VAPs. Organizations must agree upfront that they will conform to or strive for certain values for a preselected set of performance measures. This works both ways: both the superior and the subordinate are subjected to performance measure adherence. We will return to this point later.

7.4.3. Phase II - Find core processes and set task distribution

Presently the core processes of Vegpack are the following.

(a) Sourcing
- (i) engineering of packaging,
- (ii) selection and contracting of manufacturers, and
- (iii) controlling manufacturers.

(b) Distribution of pool packaging:
- (i) reallocation of pool packaging,
- (ii) ordering transport, and
- (iii) cleaning of pool packaging.

Sourcing

Every season producers communicate their planting plans to the auctions who relay this information to Vegpack. Together with the Central Auction Bureau (a cooperative owned by the auctions) a prediction of the packaging to be used that season is made. This prediction depends not only on the planting plans, but also on the marketing plans of the auctions, individual groups of producers, and on the requirements of the buyers. Based on the prediction of packages needed for the coming season orders are placed with the manufacturers. These quantities are hence fixed at the beginning of the season. During the season quantities are called off.

New carton packagings are engineered by Vegpack. Here they have to take into account the handling of that packaging in the entire chain from producer to consumer.

Auctions order packaging material once a week, and Vegpack relays the orders to manufacturers. Manufacturers of carton packaging deliver the packaging to the auctions. Notice that Vegpack is an organization operating solely in the information aspect system (IAS).

Distribution

Opposed to the one-time packaging material where the auctions are responsible for the inventory control at their premises, Vegpack is responsible for the inventory control at the auctions for pool packagings. The allocation of pool crates is based on historical information and ad hoc requests from auctions, either requesting crates or complaining about the abundance of crates at their premises. The latter will not be the case often because auctions get compensated for the storage of crates in their warehouses. Distribution is arranged on a daily basis through contact by telephone with about 70 transport companies. No long term arrangements with these transporters have been made.

Table 7.6 - Task distribution before redesign

	Manufacturer	Vegpack	Transporter	Auction	Producer
General		Yearly: Prediction of usage of packagings		Marketing plan	Planting plan
One-time carton packaging	Manufacturing Transport	Engineering Ordering		Inventory control at the auction Detailed order picking	Inventory control at the producer
Reusable Pool packaging		(Engineering) Inventory control at the auction	Transport		Inventory control at the producer

From this description the task distribution of Table 7.6 becomes apparent. Several things about this task distribution are peculiar. The first thing is that Vegpack fixes order quantities with manufacturers for an entire season. These orders are based on planting- and marketing plans which are in practice subject to change, and hence unreliable. Secondly the transport is fragmented by letting the manufacturers arrange the transport of one time packaging, not taking advantage of the economies of scale possible when transport of one-time and reusable packagings is combined.

Before proposing a redistribution of tasks, in the next phase uncertainties are assessed and opportunities for improved coordination are identified.

7.4.4 Phase III - Reengineering, status quo and breakthrough

Up till now the process description was rather straightforward and had little to do with coordination theory or inter organizational coordination. Recalling that uncertainty is the cause of coordination (chapter four) we will now assess the uncertainties in the network of organizations. Recall that we were not engaged by Vegpack to design VAPs for them. The following analysis of uncertainty and coordination was conducted to ascertain whether VAPs could be of interest to Vegpack. We will do so by *pretending* that we are designing three VAPs:

- between Vegpack and the manufacturers,
- between Vegpack and the transporters,
- between Vegpack and its customers (comprising the auctions, the producers, and the Central Auction Bureau).

Assess IU, GU, BU

The intrinsic uncertainty for the chain from producer - auction - Vegpack consists of:

- the uncertainty in yield: produce is a natural product and the actual production

depends on among other things the climate;
- the uncertainty in demand: if one day a certain packaging material is much in demand with buyers for whatever reason, producers will decide to use that packaging the next day.

GAS Uncertainty (GU) is caused by the fact that some auctions do not have a clear picture of their actual inventory. No automated inventory systems are available on the auction and the inventory level is determined weekly by a global and visual check of the packaging in store. Errors in this count cause emergency orders. Gas Uncertainty at the manufacturer and transporter are not considered at these early stages of the project. We know that the GAS uncertainty at manufacturers consists of e.g. machine breakdowns and first production run yields. For transporter the GU is determined by factors e.g. the quality of the equipment, the quality and motivation of personnel, and traffic congestion.

Boundary uncertainty manifests itself because Vegpack has no idea how the different packagings are in demand on a daily basis: not for the one-time carton packaging, nor for the reusable pool packaging. This information is of course available at the auction in the logging of the sales data. Boundary uncertainty is also caused by producers who do not adequately inform Vegpack of their planting plans for the coming season or do not communicate their change of plans. This plan is needed to specify the overall order quantities of the different packagings towards the manufacturers at the beginning of the production period.

Reengineering

The distinction in GU and BU is useful. It was clear to Vegpack and the auctions involved in the project that GU is something that the auctions must work on before anything else. Reduction of BU was something they had to work on together. From the preceding analysis of uncertainty in the chain of organizations two directions for finding redesign opportunities emerged.

(1) Boundary uncertainty between Vegpack and the auctions need to be reduced. By giving Vegpack access to the actual inventory levels at the different auctions (the client's original perception of their problem), insight in the demand pattern of the different packagings is provided. This can be taken one step further by having producers give off forecasts of their yields for a certain period in advance. This, however, does not help to cope with the uncertainty in demand for certain packagings by buyers.
(2) With this reduction of boundary uncertainty between auctions/producers and Vegpack an opportunity for closer coordination with manufacturers and transporters arises. Tighter requirements on manufacturers and transporters increases their task uncertainty, which can be coped with through coordination. Coordination is uncertainty reduction, something that Vegpack can only manage if it itself has sufficient information. The tighter requirements go hand in hand with redesign in the form of a DoF reduction and an increase in Var(M), both at Vegpack and at the manufacturers and transporters.

We will next first discuss the reduction of boundary uncertainty, a redesign which is referred to as status quo redesign. The subsequent redesigns in terms of a DoF reduction and a Var(m) increase are referred to as breakthrough, since they break with the existing way of doing things.

Reduce Boundary uncertainty

A reduction in boundary uncertainty requires two measures. First of all producers should make planting plans available that are (almost) 100% reliable. Incentive schemes are mechanisms to assure that producers indeed make this information reliably available. Secondly Vegpack should have access to:

- the actual inventory at all the auctions,
- the daily sales data of all the auctions.

This information is augmented with multi-level sales predictions from the auction marketeers and multi-level predictions regarding yields from the producers.

With the current task distribution only the first measure of boundary uncertainty reduction, accurate planting plans, will lead to a performance improvement for one-time packagings. This because the operational inventory control at the auction is the responsibility of the auction. The performance improvement can be obtained through more accurate orders with manufacturers at the beginning of the season. Both measures will lead to performance improvement for pool packagings, as Vegpack is responsible for the inventory levels of pool packaging at the auctions. The actual sales data will allow for the distillation of short term trends in demand for the different packagings.

As was stated before the reduced boundary uncertainty at Vegpack allows for improved coordination with manufacturers and transporters. This requires redesign, i.e. shifts in the redesign grid in the direction of increased Var(m) and reduced Dof.

Increase Var (M)

Rather than being committed at the beginning of the season to a fixed order quantity, Vegpack's processes need to be redesigned such that orders can be placed continuously throughout the season. Such an arrangement requires a good relationship with one's manufacturers and accurate forecast information that can be made available to these manufacturers. Orders from individual producers (as opposed to orders from auctions in the current design) are placed with Vegpack which passes them through to the manufacturer. A delivery time of one day to the yard of the producer, unless stated otherwise is required.

Closer coordination with manufacturers is obtained by exchanging multi level forecasts (see section 5.4.2). In the short term manufacturers give Vegpack insight into their finished goods inventory and expected load, and Vegpack uses this information to balance orders between the different manufacturers: Vegpack gets more variety in control actions as it can direct orders to manufacturers depending on their inventory and load.

The multi-level coordination with the manufacturers is only useful if the production processes have multiple decoupling points, as was discussed in the hypothetical case of section 5.4.2. Furthermore an increase in the variety of control actions, Var(M) at the manufacturers will lead to improved utilization of the richer information exchange, i.e. to the use of coordination to its full extent. Such an increase in Var(M) can be obtained by e.g. reducing changeover times and reducing production run lengths.

Reduce DoF

A reduction in the Dof between the manufacturer and Vegpack is obtained through the following:

- manufacturers have (less than) a one day order cycle time, and
- the manufacturers pick and pack at the level of the individual producer's order.

As a change in task distribution the transport of one-time packaging is also performed by the transporters. A few number of transporters are selected to form VAPs with. As with the manufacturers, transporters give load information to Vegpack which uses this in the allocation of transport orders. The distribution planning is performed by Vegpack, and transporters get entire routes as an order for less than truckload shipments. Deliveries are not made to the auctions but to the producers directly. The auction maintains some stock for emergencies. Vegpack may offer it as a service to the auctions to control this inventory. By having the transporters perform the transport of both types of packagings synergies and economies of scale are obtained.

The new task distribution is given in Table 7.7, the communication in Figure 7.17, and the redesigned goods flow in Figure 7.18.

Table 7.7 - Task distribution after redesign

	Manufacturer	Vegpack	Transporter	Auction	Producer
General		Demand forecasting		Marketing plan	Planting plan
One-time carton packaging	Manufacturing Detailed order picking	Engineering Ordering Inventory control at the auction	Transport	(Inventory control at the auction)	Inventory control at the producer
Reusable Pool packaging		(Engineering) Inventory control at the auction	Transport		Inventory control at the producer

Performance measures

The transporter's status messages are used to monitor the delivery reliability (time, quantity, quality) of the transporter as well as that of the manufacturer. Further Vegpack measures its own performance in terms of the quality of its forecasts. The resulting performance reports of Vegpack and of its partners are used for continuous improvement of the inter organizational relationship.

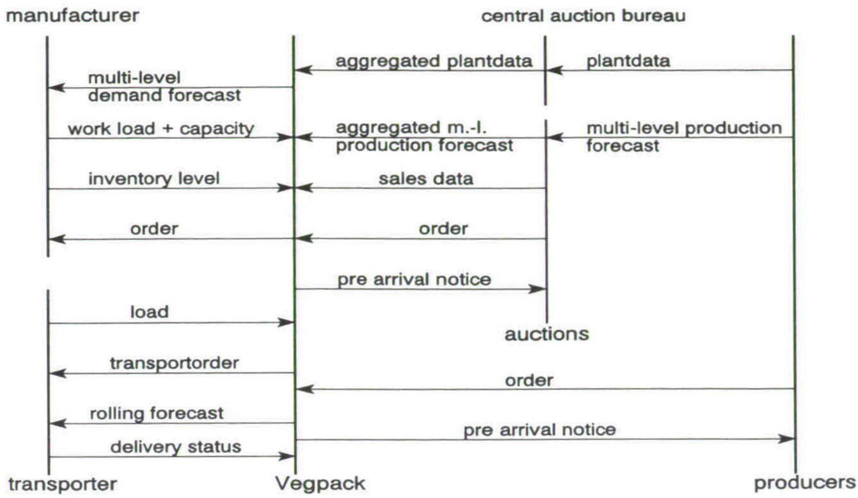


Figure 7.17 - Vegpack as the coordination centre in V&F packaging supply chain

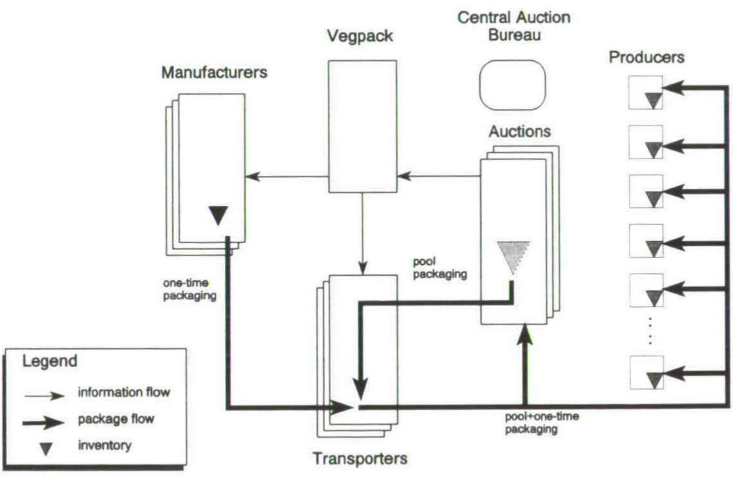


Figure 7.18 - The packaging flow after redesign

Vision before redesign

What we have essentially done in this engagement is to create a vision for Vegpack: we drew them a picture of where there business should be in about five years time. It is clear that their current operating capabilities will not be able to support this vision. The vision must serve as a mechanism to align the redesign of their processes, their organizational structure, as well as their organizational skills or competencies. Creating the vision is the first phase of our design method (Figure 6.10), which is called 'target setting' in order to cover strategic target setting, i.e. vision creation, as well as more operational target setting, i.e. determining and setting key performance measures. Having a vision is in practice very often the first step of a reengineering project. Dixon *et al.*(1994) report on a study in which twelve out of fifteen reengineering projects were initiated because management had developed a vision for the firm. Through iteration in the design method the vision is created. The more concrete a design project gets the less will be the need for iterating to an earlier phase of the method. In creating the vision forward iteration to phase II and phase III has proven in this case to be very useful.

Core competencies
We already mentioned that Vegpack's added value for its merging and thus growing customers, i.e. the auctions, no longer lies in its 'economies of scale'. In order to still be of value, Vegpack must fulfil the mission, which requires the following core competencies:
- being a full service provider for the customer in the packaging area;
- being good at pool packaging reallocation through smart, automated computer applications;
- being good at route planning, using computer support tools;
- being a forecasting expert;
- having market knowledge about manufacturers and transporters.

All these capabilities are a requisite for excellent supply chain management in the industry sector and situation of Vegpack.

7.4.5 Evaluation

Opposed to the previous two case studies (section 7.2 and section 7.3) where our role was that of an observing researcher, in this case study we were involved as a professional, and thus responsible for the outcome of the project. It is in this light that we arrive at the following evaluation.

- Thinking in core processes in useful as a means of identifying those business processes that are boundary crossing as well as relevant.

- Assessment of uncertainties, especially the concept of boundary uncertainty increases insight and stimulates thinking up solutions that may emerge once the boundary uncertainty is decreased.

- Thinking in terms of increasing the need for coordination through redesign of the variety in actions (Var(m)) and the degree of freedom (DoF), i.e. our design guideline, works.

- The method of Figure 6.10 is a useful instrument in structuring a (visioning for) redesign engagement.

7.5 Conclusions

In this section we will draw some conclusions as to how our results stood the test of reality, make our material claim, and discuss future reality tests. But first we draw some conclusions pertaining to the use of the case research method.

The case method
The case study has proven to be very appropriate for our type of study: theory building, knowledge development, and knowledge application. Such a type of study requires extensive desk research, or as Stamper (1973) calls it: "excursions into cloud cuckoo land". To prevent the researcher from wandering too far away from reality into metaphysical country, it is a prerequisite that such a study has a large real life component, which should preferably be conducted simultaneously with the desk research. The case method is much more suitable for this purpose than e.g. survey research or expert interviews, because the researcher himself enters reality, either as an observer or as a participant. For theories which aim to cover maiden territory this is an absolute necessity. Furthermore our theoretical constructs, as well as our design tools, require extensive knowledge of a real life practical situation.

Workability
The major outcome of our case studies in our opinion is that our design knowledge *works*. The theory can be operationalized and the theoretically derived directions for reengineering can be applied to real life cases. We must contend and emphasize that these directions merely direct the search for alternatives, and that (re)designing remains a highly creative process. The modeling approach can capture all relevant characteristics of the real world. The process view brings clarity to the many actions within real business operations, and the process decoupling point has proven to be a useful concept. We find that the communication design tool and corresponding guideline, and the communication partitioning tool are very useful, and close to the world of the business designer, i.e. directly applicable.

External validity
External validity is concerned with the class of design problems to which we can claim to extend the applicability of our design knowledge.

Material claim

- Our experience in the case studies leads us to the claim that our knowledge for design is applicable in inter organizational settings with recurring transactions under organizational relationships covered by a contract, i.e Value adding partnerships.

Constraints
Just as important as the material claim is the indication of areas where the design knowledge does not apply.

- The knowledge is not applicable in organizational settings called electronic markets (see chapter one). Here recurring transactions may occur but they are not governed by contract. Though coordination and negotiation also take place in these settings (see Sandholm (1993) for coordination principles in an electronic market for transportation), different design principles apply.

- The knowledge is also not necessarily applicable in VAPs of more that two organizations, although many of the concepts can be found in other than dyadical VAPs. Our claim of applicability is therefore restricted to dyads.

Tests

The objective of the case research, beside exploration, was to proof the *workability* of our design knowledge. The *external validity* of our design knowledge will improve through:

(a) more applicative case studies, e.g. in consulting engagements,
(b) the application of in particular the knowledge *for* design by other persons than the researcher who developed the knowledge.

Whether the latter is possible depends on the *understandability* (Volberda 1992, Van Aken 1995) of our design knowledge. In chapter eight we will recommend some further research to test our research product on this criterion. In this study we suffice by leaving this test to the reader.

Chapter Eight

Evaluation

"There were many problems that she hadn't solved. But is wasn't for lack of trying. She hadn't given up. She had run out of time."
- **Tracy Kidder**, Among schoolchildren, 1989.

In this chapter we summarize this study's results, and assess its relevance and limitations. Positioning is sought by comparison with elements from theory and practice. Being a study in organizational science, the implications for the people who do the organizing are briefly assessed, and the use of the theory developed as a design theory is described. Implications for academia are given in terms of research needed to further support the current results and theoretical extensions deemed relevant to broaden the applicability of the theory.

8.1 The study in perspective

8.1.1 Summary and Contribution

A lot is being speculated about redesigning logistics, and many of the redesign opportunities are attributed to information- and telecommunications technology (ITT), in particular to EDI. The point of departure of this research has been that if EDI can induce redesign, it will do so through the improvement or redesign of the coordination of logistics between organizations. It is our (methodological) inclination, that any effort of (re)design should be preceded by an understanding of the object to be (re)designed. The objective of this research has been to provide knowledge *on* the (re)design (object knowledge) and knowledge *for* the (re)design (process knowledge) of the operational part of inter organizational relationships with specific emphasis on their logistical processes and the role of EDI therein. This objective was translated into a theoretical or understanding problem and a practical or engineering problem (see chapter one). Our contribution to these problems is described, along with our experience in conducting theory development and (re)design oriented research.

Theoretical contribution. In this study we have laid a foundation for a theory of logistics coordination. As a first requirement for every theory, a *description or vocabulary* of the area of attention is given, in terms of concepts (the units of the theory), laws of interaction, and classifications. These concepts give new, improved, representations of reality, on which improved explanations and predictions can be based. *Explanation* of coordination was given in terms of its causes and effects. This theoretical basis allowed for *predictions* pertaining to the effect of EDI on coordination, along with an indication of the directions in which one must search in order to find EDI induced redesigns. These redesign guidelines represent the practical application of the theoretical insight.

Engineering contribution. Two design support tools with guidelines and a method for the (re)design of coordination in VAPs have been developed. Further a language for modeling logistical processes, and a simulation tool for the specification and evaluation of alternative designs have been developed.

Methodological experience. Simulation was shown useful as a means of operationalizing constructs and illustrating theoretical predictions in hypothetical case studies. The case study approach was used as a descriptive instrument to bridge the gap between theory and reality, and also served as an inductive instrument for the development of both the theory and the design tools.

We have been able to describe and explain why organizations communicate and what coordination mechanisms they may employ. The main claim of this theory is that coordination leads to uncertainty reduction and that EDI's main effect is a further reduction of this uncertainty. Ultimately this reduced uncertainty will result in reduced slack or improved customer service (lead time and delivery reliability) or both. This insight enables predictions regarding the redesign capabilities of EDI, which although not specific 'cookbook' rules, enable a directed search for redesign opportunities. These opportunities depend on the data relationships between OUs, the susceptibility of the current processes to uncertainty reduction, and the potential for changing the variety in actions of the OUs and their degree of freedom (DoF).

8.1.2 Relevance of the results

Although the topic of coordination has been treated before, this has been either abstract (mathematical) or centred on the coordination internal to organizations (between people, or within production planning). We have described and explained inter organizational logistical coordination in dyads. The logistics coordination theory partly draws from and integrates fragments of theory presented elsewhere. Throughout, the development was guided by the use of EDI as a means of communication.

The topics of coordination in itself and subsequently its (re)design are becoming increasingly relevant, because of both pull (business needs) and push forces (technological advancements). Our study advocates a fundamental approach to (re)design of coordination, rather than using (ad hoc) rules of thumb or applying anecdotally supported success factors. Further theoretical support for design is needed, and our theory can be used as a starting point as well as a guide to routes for theoretical extension. Moreover it provides a basis for directing empirical research. E.g. are practical improvements in performance which are attributed to EDI really a consequence of EDI? Or is EDI merely a catalyst for change which would have also occurred without EDI? The engineering results from our study are on the one hand readily usable, and on the other a subject for further exploration and development.

8.1.3 Findings and conclusion

The main findings of this study are enumerated next.

- Coordination leads to uncertainty reduction, which ultimately results in improved performance (reliability, cost, lead time).
- EDI can enhance coordination in a VAP, i.e. reinforce uncertainty reduction, by enhancing the decision making aspect and communicating aspect of the coordination mechanism.
- The potential of EDI for redesign (see Table 4.2) depends on the logistical processes, i.e. the internal control problem characteristics of the constituent OUs, especially their susceptibility to uncertainty reduction, and the possibility of entirely new internal control policies which employ the reduced uncertainty.
- Directions for the search for EDI induced redesign opportunities are the reduction of Degrees of Freedom (DoF), and the increase of the variety of actions of OUs.
- The value added by a VAP is its reduced uncertainty during operations as a consequence of one-off coordination in the design phase.
- EDI is a formalized means of communication. In an environment with rare or unforeseeable disturbances the need for an informal channel will remain. Resolving interference between the formal and informal channel is an important design issue. So is the assurance that OUs at all times have the same perception of their shared state of processes.
- Simulation is a useful instrument for the illustration of theory.
- As a dyad is only part of a chain or network, the need for coordination may arise at the boundaries of the dyadical VAP.

The study leads to the following overall conclusion/viewpoint.

- Interorganizational coordination should not be looked upon as a necessary *glue* as in intraorganizational coordination. Rather interorganizational coordination must be thought of as an *enabler* of and *opportunity* for improved performance.

8.2 Limitations of the study

Apart from the limited applicability of the results due to the research demarcation, the following topics are recognized as important but were not considered in this study.

The *variable "human"* has been ignored throughout the research. It is an important variable, not only in the acceptance of a design, but also as a part of it. E.g. elaboration is required on how the Level C design with humans and their inherent process flexibility (as opposed to the rigidity of an information system) is to be designed.

Strategic behavior e.g. power play, self-interest, and opportunism during the design phase of the VAP, may result in a design which is not the best from both parties' point of view, nor from a logistical viewpoint. The term 'partner' in practice does not refer to 'equal' or 'friend'. Such phenomena have also been disregarded, although they are critical success factors for the realizability and viability of a VAP design.

We also ignored the start up period of a VAP in which design errors emerge and are ironed out. Our engineering problem only focused on the design phase, the period in which the blueprint is (re)designed, and not on the blueprint implementation period. This *dichotomous representation* of design viz-a-viz implementation is flawed for most practical business redesign (see e.g. Ramondt et al. 1993), since organizations need to be changed while they remain operative, and designs are often adjusted during implementation.

The study also has some methodological limitations. We agree with Popper that theory cannot be verified. However theory should be constantly subjected to critical appraisal and tests of, in the case of a design theory, workability. The predictions of the theory, the design guidelines, were only tested in the simulation case study, i.e. the performance improvements resulting from the redesign were measured. More tests of the theory should be performed, especially in empirical cases where (re)designers really obtain performance improvements through uncertainty reduction.

While a method can neither be verified nor falsified, its usefulness (in comparison to other methods) can be shown. Our method was partly based on practical experience in one of the case studies, and partly derived from the theory. We did return to reality to show the usefulness of the method, but did so only in one case, and only for part of the method (the first three phases). Overcoming these methodological limitations should be of high priority, if one is to carry further the results of our study.

Testing of the knowledge on design (the method, including the tools and guidelines) is a matter of continuously traversing the cycle of application and adaptation until a steady state is reached. This is considered a fairly straightforward process, which will not be elaborated upon. For the testing of the knowledge for design, the theory, a recipe is given in section 8.5.1.

8.3 Positioning

In this section the relevance of this study is given through positioning relative to a topic of current interest in organizational science, i.e. transaction cost economics (TCE). TCE is chosen since this is a well advanced and much used theory that, just as coordination theory, deals with interorganizational relations.

The aim of our theory is to support the business designer of VAPs. In this section we contrast our theory to the transaction economist's reasoning as described in section 3.4. Although they are different in aim - operational design of relationships viz-a-viz explanation of emergence of relationships - the theories possess similarities as is shown below. The purpose of this exercise is to position our theory relative to an established body of knowledge and to further illustrate its potential as a vehicle for reasoning.

Rather than having a confrontation on the generic level, a single proponent of transaction cost theory was chosen. Aertsen (1995) has not only developed a model derived from transaction cost theory to explain why organizations subcontract their physical distribution activities, but he has also tested the model in no less than 28 cases across three different industry sectors. As physical distribution is a typical business area for VAPs, we found Aertsen's study very close to our own study. His model which is self-explanatory is given in Figure 8.1.

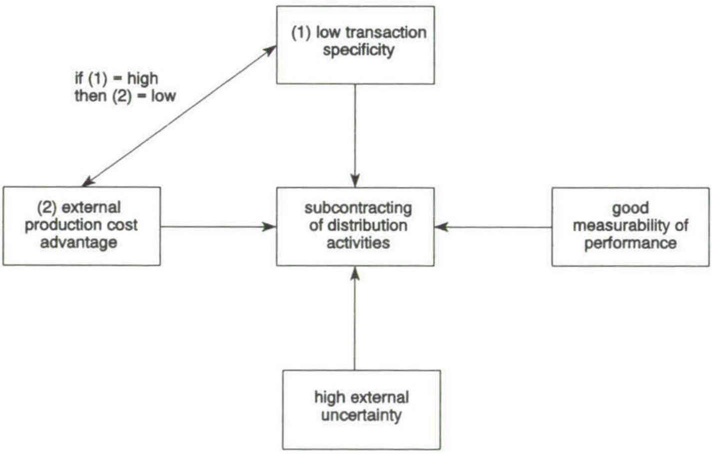


Figure 8.1 - Factors leading to subcontracting based on transaction cost economics (Aertsen 1995)

The basic line of reasoning in transaction cost economics is that an activity is internalized when the internal coordination and production costs are lower than the external transaction and production costs. In terms of our theory the external transaction cost are our cost of coordination. As the need for coordination between two OUs is proportional to the boundary uncertainty (BU) the line of reasoning in term of logistics coordination theory is as follows.

> *The higher the BU, the higher the need for coordination, the lower the probability of subcontracting.*

How does our theory correspond to Aertsen's model? Clearly we have not included two of his constructs: *production cost advantage* and *transaction specificity*. Links to the constructs *measurability of performance* and *external uncertainty* do exist as shown in Figure 8.2. Also depicted in Figure 8.2 are two of Aertsen's propositions and two corresponding propositions of logistics coordination theory in combination with transaction cost theory. These links between constructs and the two sets of propositions are discussed next.

Required Performance and Measurability of Performance
Monitoring of the subcontractor is needed to keep track of actual performance and take corrective measures in case of deviation. This is particularly important is case of high required performance. It is therefore postulated that the higher the required performance of a VAP or OU, the higher the need to monitor subcontractor performance. Measurability of performance becomes an important factor, and the status 'good' becomes increasingly difficult to obtain. The higher the required performance, the higher the task uncertainty, the higher the boundary uncertainty, the higher the need for coordination, the lower the probability of subcontracting. In this respect the reasoning based on logistics coordination theory is consistent with Aertsen's model.

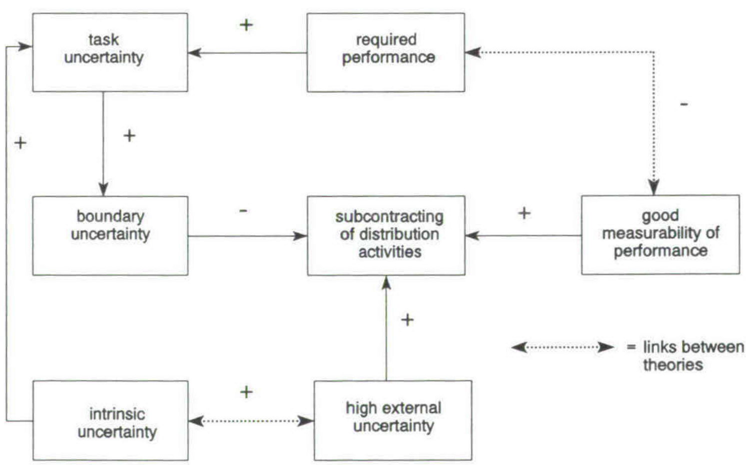


Figure 8.2 - Conflict and consistency between coordination theory and Aertsen's model

Intrinsic Uncertainty and External Uncertainty
Aertsen's external uncertainty corresponds to our notion of demand uncertainty. The higher the intrinsic (demand + supply) uncertainty the higher the need for coordination, the lower the probability of subcontracting. Here our conclusion differs from Aertsen's proposition. Aertsen states that the literature is not consistent on whether uncertainty reinforces subcontracting or not. His own research does not support this proposition either. He contemplates that a relation between subcontracting and uncertainty exists through the characteristics of the assets needed to cope with the variation in demand, but does not elaborate. If this is done, the concept asset-characteristic can be linked to the concept internal design of logistics coordination theory. In coordination theory the internal design is one of the determinants of task uncertainty, the relation of which to subcontracting is shown in Figure 8.2. Elaboration of Aertsen's model with the concept asset-characteristic would point out whether both theories are consistent in this respect. The fact that external uncertainty itself is not an explanatory concept supports the strength of the concept task uncertainty.

The other two propositions pertaining to *transaction specificity* and *production cost advantage* in Aertsen's model are according to the researcher both supported by the case evidence. Logistics coordination has no direct link to transaction specificity. Logistics coordination can, however, explain how a subcontractor can obtain a production cost advantage. Such an external production cost advantage can be obtained when a subcontractor has more than one customer. (As our logistics coordination theory focused on dyads the following important phenomenon was not discussed before.) Suppose a subcontractor, S, has n customers, OU_1, OU_2, ..., OU_n and has a task uncertainty TU_S. Assuming a one-to-one dyadical VAP between S and OU_i the portion of the TU_{VAP} transferred to S would have been $TU_{S,i}$ (see Figure 4.17). A production cost advantage by the subcontractor can be obtained because of the following inequality:

$$\Sigma \, TU_{S,i} \geq TU_S \qquad (1)$$

Equation (1) for instance holds when two customers of S have anti-cyclical seasonal patterns. Meeting the required performance is more difficult when these customers are served separately than when they are served by a single service provider. This may lead to production cost advantage for the service provider relative to the production cost if the superior were to perform the task himself.

An interesting issue related to the transaction cost economics pertains to the viability of VAPs. Consider the following argument.

> The cost of designing a VAP, Cost (O $\rightarrow$ N), is so high (including the asset specificity), that in order for the effort to pay itself back, the duration of the contract will be too long and beyond the scope of which organizations are willing to commit themselves. The longer the duration of the contract, the higher the strategic environmental uncertainty the decision makers face at the time of contracting.

This raises the question: 'Under what circumstances will VAPs emerge?" See Williamson's (1991) argument on the viability of hybrids in terms of asset specificity (required investment) and frequency of disturbances (see Figure 8.3). As information technology reduces the cost of coordination "... will VAPs not become obsolete in the end?" (recall Malone *et al.*'s (1987) argument for less hierarchy and more market discussed in chapter three). Will this reduction in coordination cost ultimately lead to the 'virtual organization' (Mowshowitz 1987)? What is the role for standardization in this field of forces?

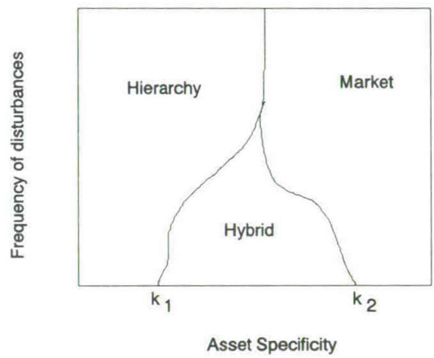


Figure 8.3 - The viability of hybrids: as the frequency of disturbances increases the hybrid (VAP) as a design option disappears (source: Williamson 1991)

8.4 Implications for business practitioners

We partition the implications to those for business designers (the people in an organization responsible for its design), consultants, and service and software providers, which are not necessarily mutually excluding groups.

Business (re)designers
In their decision to adopt EDI business practitioners should weigh not only the immediate efficiency benefits, but also the potential benefits as a consequence of redesign. This study supports the search for these redesign opportunities. The tools and guidelines can be readily used.

Business consultants
We perceive business consultants as the ideal intermediaries between the business and academic world. They should stay in tune with the developments in the academic world and translate or apply them to practice, and should vice versa communicate requirements for fundamental research. Because of their practical experience, they are better equipped

than the organizational scientist to apply the fruits of science. This does not apply to the organizational scientist who uses the clinical research method in which the researcher combines the roles of scientist and consultant in a specific problem situation (see Volberda 1993 for an elaborate discussion on this topic). This study provides consultants with insight and thus a foundation for devising instruments and tools to be used in the consulting process.

Service and software providers

This study both underlines the potential of EDI to change ways of working, and gives insight into what changes might be possible. The sellers of ITT need to be aware of the effects their core product may have on organizations. They should therefore add to their product - even if only for marketing purposes - the consulting needed to use the core product effectively.

8.5 Implications for academia: further research

8.5.1 Theory testing

In this dissertation we have presented a theory of logistics coordination. Given the objective in this study, the theory is more an instrument than a goal in itself. 'Verification' or 'falsification' (depending on one's philosophical inclination) was therefore limited to illustrating that the concepts allow for reasoning for (re)design. Besides, it is practically beyond the scope of a single dissertation to come to a grounded conclusion whether this theory should be accepted or rejected. Acceptance depends on the ability of this theory to guide practice, both organizational (business (re)design) and scientific (research).

If our logistics coordination theory is to be taken a step further into 'theoretical country' as will be recommended in the next section it should be subjected to further empirical tests. We agree with Putnam (1991) that just as there are no rigid algorithms for theory construction, there are no rigid algorithms for theory testing (despite the numerous textbooks on the subject).[1] Still in this section we will give some guidance on the actions to be undertaken in order to come to the acceptance or rejection of our theory.[2] The propositions derived from the theory that are considered relevant and eligible for testing are listed in Table 8.1.

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[1]According to Putnam (1991, p.134) "There are maxims for discovery and maxims for testing: the idea that correct ideas just come from the sky, while the methods for testing them are highly rigid and predetermined, is one of the worst legacies of the Vienna Circle".

[2] Notice the use of the term 'acceptance' rather than verification.

Table 8.1 - Research guiding (testable) propositions

Type of proposition	No.	Proposition
Descriptive	1	Operational data in organizations fall into either of the following categories: coupling, goal, status, model data
Descriptive/ interactive	2	Tasks uncertainty is determined by Intrinsic Uncertainty, Required Performance, and Internal Design
	3	Task uncertainty can be matched by: coordination, deviation from required performance, and emergency measures
Predictive	4	DoF reduction increases the need for coordination to a certain extent
	5	Increase in Var(M) increases the need for coordination to a certain extent

One criterium to ascertain the scientific status of a theory is the operationalizability of (some of) its concepts, which implies the refutability of the theory. In the case studies of chapter seven we have shown this for logistics coordination theory. The first proposition can be easily tested by application to a number organizations, or confrontation with the literature, e.g. on management information systems. In our opinion there are three relevant questions that need more elaborate investigation than performed sofar:

(1) *Do the relationships between concepts hold? (descriptive nature of the theory)*
(2) *Are the directions for redesign useful? (instrumental aim of the theory, predictive power)*
(3) *Does the theory improve understanding? (instrumental aim of the theory)*

The first question pertains to propositions 2 & 3 of Table 8.1, the second question to propositions 4 & 5, while the third question pertains to all five propositions. For each question a research design is suggested (see Figure 8.4 for a summary).

Case studies are proposed for answering the first and second question. The case study is the preferred method for two reasons. First of all operationalization of the concepts is very situationally dependent and not a straightforward task. Answering the question 'what is the level of task uncertainty' is not possible without a profound understanding of the concept. This for instance disqualifies the survey as a method. Secondly quantification of concepts once operationalized is difficult. This is not a drawback since the theory tries to give insight in interaction (and trade-offs) between concepts rather than into the values for specific concepts in an organization.

As to the first question we suggest discrete longitudinal case studies in which the unit of analysis can be single organization. The organization should be going through a process of redesign so that the constructs can be 'measured' at two points in time. This is needed because the concepts are difficult to quantify and the nature of the propositions is such they can best be illustrated by trade-offs between concepts. This requires at least two points of observation. The reasoning of chapter five, where in each case a before- and after-redesign situation were discussed, can serve as an example in analyzing the case material.[3]

The following steps should be taken, at both points of observation.

(1) Describe the required performance.
(2) Describe the internal design: decoupling points (level, location), forecasting.
(3) Describe the environment and the GAS (Ψ)
(4) Describe coordination with suppliers and customers.
(5) Measure the actual performance.
(6) Describe emergency measures and their cost.

Subsequently the two situations should be compared and the final step is:

(7) Assess whether the trade-offs between variables before and after redesign are consistent with propositions 2 & 3.

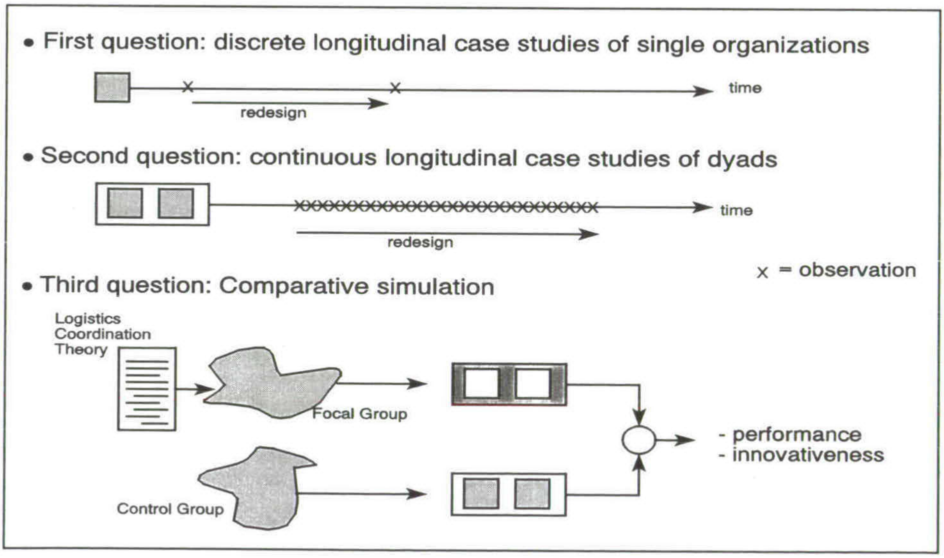

Figure 8.4 - Recommended research designs for theory testing

[3] That a *single* organizational unit (rather than a *dyad*) can serve of the focus of analysis in testing the first three propositions (the first question) is not surprising in one recalls from chapter four that in the beginning of our theory building the dyadical VAP was treated as a black box, i.e. as a single OU. The concept coordination then pertains to coordination with the environment, i.e. customers and suppliers.

To answer the second question continuous longitudinal case studies are recommended. The unit of analysis should be a dyad. Furthermore the partnership must be in a period of redesign, during which the case researcher is present (either in a passive or active role). Apart from the steps 1-6 above the researcher should assess whether a proposal for redesign falls into one of the two categories 'increase Var(M)' or 'reduce DoF'. If so the effect on the need for coordination between the two OUs (or between the OUs and the environment) should be assessed. Again the line of reasoning followed in chapter five can serve as an example.

The third question pertaining the potential for improving the understanding of the theory is the most difficult to investigate, because understanding and insight are such intangible notions. A gaming situation is suggested with two groups of 'business designers': one group that has been lectured in logistics coordination theory, and a control group that has not been prepared for the design task. In each group the participants play members of two organizations that have decided to form a VAP and to use EDI. Their task is to devise a design for the VAP. Comparison of the outcomes, i.e. designs, of the groups should answer question three, i.e. whether the lectured group has come up with superior and more innovative designs.

8.5.2 Extension of this study's results

Our study has laid the foundation for a theory of logistical coordination, has made predictions regarding the potential of EDI induced redesign, and has employed a methodology for conducting research to further this theory and its practical application. We feel that from these mere foundations an entire building of logistical coordination theory and research should arise, and are supported in our feeling by the practical relevance of the topic. Alterations of the foundation at certain points is certainly not excluded since all theory is only tentative. The opportunities for building on our foundation are many, and some are presented here using Popper's (1972) three tasks of science: theory building, prediction, and practical application.

Theory Building

The coordination theory could be extended in width as well as in depth. With the in-width extension, the incorporation of the money aspect system (MAS) and the application to other types of coordination than logistical coordination is meant. The following classification of organizations (see Figure 8.5) could be used in choosing other areas of application.

We propose the following stepwise approach for the in-depth extension.

- Study coordination in triads. This modification allows for the two other types of interaction (other than coupling): resource sharing and target sharing (see chapter four). Also in triads OUs can participate which can fully take on the coordinator functionality on behalf of the other two OUs in the triad (e.g. forwarders). This will probably result in new insight into the mechanisms of coordination.

- Next study the coordination in chains ($n \geq 3$). With a chain we denote the simplified case in which each customer has one supplier. An interesting issue in a chain is the coordination pattern: is the logistics chain a concatenation of dyads, or a concatenation of dyads and triads, or will new patterns emerge? Will these new patterns result in new coordination mechanisms? Are there uncertainty amplification effects in chains? And how can these be avoided?

- Finally, study coordination in networks. With a network we mean logistics chains without the single supplier assumption made in the previous step. What will be the effect of pooling uncertainty of multiple customers and suppliers?

In the research the communication- (including the speech act theory) and control theory are not integrated at a conceptual level with the coordination theory. Integrating these into a coherent body of knowledge would result in an elegant explanation of operational business interaction.

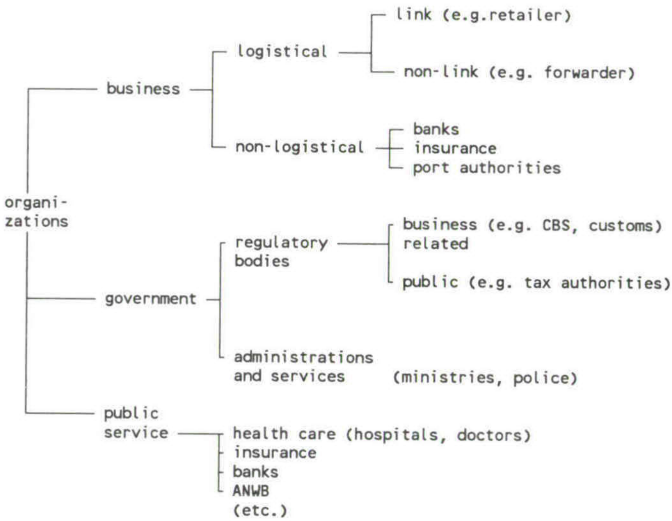

Figure 8.5 - Taxonomy of organizations: the coordination theory can be extended to other than logistical organizations

Prediction

The redesign guidelines presented in section 4.5 were derived without trying to be complete. The search for more rules and further enhancement of the presented rules will be of great relevance to the appreciation of the theory. Development of more design rules is hence recommended.

Practical Application

Empirical case studies of the design of VAPs in which the design rules and methodology are applied are recommended for further research. This will results in testing and refining of the method and the rules, and further validation of the practical usefulness of our modeling approach of logistics and accompanying simulation tool.

Tools and Instruments

The simulation tool served as a research instrument in our study, and not as a reengineering support environment (RSE) for the business practitioner, although it has the operating core to fulfil this function. Before the simulation tool is enhanced other tools need to be assessed. Some strong points of our tool are its ease of programming due to the PSL front end, and its one-to-one correspondence with the modelling approach of section 5.3. The latter implies the tool's explicit inclusion of databases in the simulation model and the modeling of tasks and their triggering (processes) instead of equations (as e.g. in system dynamics). The following suggestions for modification of the simulation tool are indicative of its current weaker points as a RSE:

- development of a graphical specification interface,
- improved animation,
- development of analyses, e.g. order critical path determination through simulation.

The IR state diagram can be formalized and more normative rules for its use can be developed. Also of interest would be a typology of generic IR state diagrams.
The static-dynamic design guideline can be elaborated upon as follows. Can rules be devised for separating them? Once they are separated, what part of the dynamic design will be implemented in the formal channel and system, and what part by the informal channel? How should the reconciliation be approached? Case study research would be needed to explore this problem further. Database literature could be a candidate for theoretical answers to the reconciliation problem, since this problem is also prevalent in distributed databases.

Towards a research programme of inter organizational coordination

The previously suggested topics for further research could be transformed into a programme on coordination in general. A rough outline of such a programme is given, by presenting its empirical point of departure, its meta-hypotheses, its theories, and its methods.

A research programme on coordination derives its *relevance* from the following observable empirical facts.

- The share of services is increasing in the overall economic activity (see Ministry of Economic Affairs 1991).
- The management of relationships with other organizations in the same (logistics) chain is very important in today's turbulent business environment.
- Information and communications technology (ITT) enable organizations to deal with complexity and variety.

The following *meta-hypotheses* represent the line of reasoning followed in our study, and are considered applicable to an encompassing programme. They provide a framework for conducting research within the proposed programme on coordination research. Within brackets the required results are given.

(1) Using ITT without redesigning processes, i.e. to merely speed up communication and processing, is not exploiting ITT to its full potential.

(2) It is possible to redesign business processes through modeling and simulation. [modeling support tools, simulation tools]

(3) In the modeling of business processes it is essential to observe information-, goods-, and money flows in an integrated manner, in order to capture the trade-offs between design variables in different aspect systems.
[modeling approaches (- paradigms)[4]]

(4) Distributing tasks across organizational boundaries whilst achieving a desired level of performance requires inter organizational coordination. Knowledge of coordination is required.
[understanding coordination (building/using coordination theory)]

(5) Inter organizational coordination can be improved by ITT.
[effects and rules for (re)design]

Notice how such a research programme is consistent with the view of organizational science as a field comprising both organizational design (or engineering) and organizational analysis (see chapter two). The *theories* of this programme will entail, apart from the coordination theory under development, logistics theory and operations research as supporting bodies of knowledge. If one wishes to assess the impact of strategic behavior on the design (see section 8.1), theories such as agency theory, and sociological theories on power should be included.

The preferred *methods* would be computer simulation experimentation for illustrating, testing, but also building theory, and case study research for exploration (issue finding), illustrating concepts and testing predictions. We need to use the computer as a laboratory in organizational science because our objects of study are not eager to be experimented upon, and we do not, unlike the medical researcher have rats and mice to use as substitutes. Realistic and hence complex representations of design will often not be fully captured by equations and operations research models, reason why simulation is proposed as a method. To bridge the gap with reality, validation will be an essential task. For the same reason as above, the complexity of designs, but also because of the complexities of the redesign processes in organizations, the case study approach is best suited for research on organizational (re)design.

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[4] A modeling approach or paradigm can make reference to other theories, e.g. agency theory, or speech act theory.

8.5.3 Concluding remark

Given the preceding outline of a coordination research programme, we must in retrospect admit that ours was only a brief encounter with the interesting phenomenon called coordination.

References

Aalst, W.M.P. van der, *Timed coloured Petri nets and their application to logistics*, Doctoral Dissertation, Technical University Eindhoven, 1992.

Abell, D.F., *Defining the business: the starting point of strategic planning*, Prentice-Hall, Inc., 1980.

Ackoff, R.L., *A concept of corporate planning*, Wiley-Interscience, 1970.

Ackoff, R.L. and F.E. Emery, *On purposeful systems*, Tavistock Publications, 1972.

Aertsen, F., *Executie van fysieke distributie?*, Doctoral dissertation, Catholic University Brabant, 1995.

Aken, J.E., *On the control of complex industrial organizations*, Doctoral dissertation, Technical University Eindhoven, Martinus Nijhoff, 1978.

Aken, J.E., "Het ontwikkelen van wetenschappelijke kennis voor organisatieprofessionals vanuit spelersperspectief: de rol van ontwerpmodellen en heuristieken", *M&O Tijdschrift voor organisatiekunde en sociaal beleid*, 48, 1994, pp.388-404. (in Dutch)

Aldrich, H., "An organization-environment perspective on cooperation and conflict between organizations in the manpower training system", Negandhi, A.R. (ed), *Inter organization theory*, The Kent University State Press, 1975, pp.49-70.

Alkemade, M.J.A.,"Complexiteit, een verkenning", Alkemade, M.J.A. (ed.), *Inspelen op complexiteit: mens techniek, informatie en organisatie*, Samson Bedrijfsinformatie, 1992 (in Dutch).

Andersson, P., H. Aronsson and N.G. Storhagen, "Measuring logistics performance", *Engineering costs and production economics*, 17 (1989), pp.253-262.

Antonelli, C.A., "The new industrial organization approach", C.A. Antonelli (ed.), *New information technology and industrial change*, Kluwer Academic, 1988a, pp.1-12.

Antonelli, C.A., "The emergence of the network firm", C.A. Antonelli (ed.), *New information technology and industrial change*, Kluwer Academic, 1988b, pp.13-32.

Antonelli, C.A., "The economic theory of information networks", C.A. Antonelli (ed.), *The economics of information networks*, Elsevier Science Publishers B.V., 1992.

Ashby, W.R., *An introduction to cybernetics*, Third Impression, John Wiley & Sons Inc., 1958.

A.T. Kearney, *Logistics Productivity: the competitive edge in Europe*, A.T. Kearney, 1987.

A.T. Kearney/Knight Wendling, *Value Added Logistics: meer toegevoegde waarde in de gateway door industriële en logistieke dienstverlening*, A.T. Kearney/Knight Wendling, 1993. (in Dutch)

Attkisson, C.C. and A. Broskowski, "Evaluation and the emerging human service concept", C.C. Atkisson *et al.* (eds.), *Evaluation of human service programs*, Academic Press, 1978, pp.4-7.

Baarda, D.B. and M.P.M. de Goede, *Basisboek methoden en technieken*, Stenfert Kroese, 1990. (in Dutch)

Backler, G., "Co-Makership relations in European distribution", *The international Journal of Logistics Management*, Vol.2, No.1, 1991, pp.48-51.

Bakos, J.Y., "A strategic analysis of electronic marketplaces", *MISQ*, September 1991, pp.295-310.

Baligh, H.H., "Decision rules and transactions, organizations an markets", *Management Science*, Vol.32, No.11, November 1986, pp.1480-1491.

Bartee, E.M., *Engineering experimental design fundamentals*, Prentice Hall, Inc., Englewood Cliffs, N.J., 1968.

Benjamin, R.I., D.W. De Long, and M.S. Scott Morton, "Electronic Data Interchange: how much competitive advantage?", *Long Range Planning*, Vol.23, No.1, pp.29-40.

Bertels, K. and D. Nauta, *Inleiding tot het modelbegrip*, Uitgeverij W. de Haan, Bussum 1969. (in Dutch)

Birtwistle, G.M., *DEMOS - A system for Discrete Event Modelling on Simula*, Macmillan, 1985.

Boekee, D.E. and J.C.A. van der Lubbe, *Informatietheorie*, Delftse Uitgevers Maatschappij, 1988. (in Dutch)

Boesten, M.E.W., "IKZ moet groente- en fruitsector meerwaarde opleveren", *Voedingsmiddelen technologie*, 1995, No.8, pp.11-13. (in Dutch).

Bolwijn, P.T. and T. Kumpe, *Marktgericht ondernemen - Management van continuiteit en vernieuwing*, Van Gorcum/Stichting Management Studies, Assen/Maastricht, 1992. (in Dutch)

Bosman, A., "Ontwerpen, procesmodellen en beslissen", *Informatie*, Vol.28/1986, No.4, pp.257-360. (in Dutch)

Borys, B. and D.B. Jemison, "Hybrid arrangements as strategic alliances: theoretical issues in organizational combinations", *Academy of Management Review*, 1989, Vol. 14, No.2, pp.234-249.

Bowersox, D.J., *Logistical Management*, MacMillan, 1986.

Bowersox, D.J., "The strategic benefits of logistics alliances", *Harvard Business Review*, Vol.68, July-August 1990, pp.36-45.

Broekstra, G., "Management by matching- De logica van effectief strategisch Management", *M&O*, 1986/6, pp.502-515. (in Dutch)

Broersma, H., "Co-Makership stelt hoge eisen aan partners", *B&id*, Vol.3, 1991, no.3, pp.7-10. (in Dutch)

Brooke, G.M., *Information technology and productivity: an economic analysis of the effect of product differentiation*, Doctoral dissertation, University of Minnesota, 1990.

Burns, W.J. and F.W. McFarlan, Information technology puts power in control systems, *Harvard Business Review*, September-October, 1987, pp.89-94.

Butler Cox, *Electronic Marketplaces - Management summary*, Report 77, November 1990.

Canna, E., "A Supermarket for transport services", *American Shipper*, May 1992, pp.45-51.

Child, J., *Organizations: a guide to problems and practice*, Harper and Row, 1977.

Chin A Lien, K., *Een simulatietool voor logistieke processen*, Masters Thesis, Erasmus Universiteit Rotterdam, 1993.

Christopher, M., *The strategy of distribution management*, Glower Publishing Company, 1984.

Coase, R.H., "The nature of the firm", *Economica*, 1937, 4, pp.386-405.

Cooper, R. and R. Kaplan, *The design of cost management systems*, Prentice Hall Inc., 1991.

Conant, R.C., "Laws of information which govern systems", *IEEE Transactions on systems, man, and cybernetics*, Vol. SMC-6, No.4, April 1976, pp.240-255.

Conant, R.C., "Communication without a channel", *International Journal of General Systems*, Vol.5, 1979, pp. 93-98.

Cooper, J., M. Browne and M. Peters, *European logistics - Markets, management and strategy*, Blackwell, 1991.

Coyle, J.J., E.J. Bardi and C.J. Langley, Jr., *The management of business logistics*, West Publishing Company, 5th edition, 1992.

Creemers, M.R., *Transaction Engineering*, Doctoral Dissertation, University of Amsterdam, 1993.

Crookall, D. and D. Saunders (eds.), *Communication and simulation: from two fields to one theme*, Multilingual Matters, Ltd, pp.3-29.

Cunningham, C. and C. Tynan, "Electronic trading, inter-organizational systems and the nature of buyer-seller relationships: the need for a network perspective", *International Journal of Information Management*, 1993, 13, pp.3-28.

Dahl, O-J., "Discrete event simulation languages", F. Genuys (ed), *Programming languages*, Academic Press, 1968, pp.349-395.

Daft, R.L. and R.H. Lengel, "Organizational information requirements, media richness and structural design", *Management Science*, Vol.32, No.5, May 1986, pp.554-571.

Davenport, T.H. and J.E. Short, "The new industrial engineering: Information technology and business process redesign", *Sloan Management Review*, Summer 1990, pp.11-27.

Davis, T., "Effective supply chain management", *Sloan Management Review*, Summer 1993, pp.35-46.

Dewitz, S.D., *Contracting on a performative network: using information technololgy as a legal intermediary*, Doctoral dissertation, The University of Texas, 1992.

Dietz, J.G.L., "A communication oriented approach to conceptual systems modelling", *Proceedings of the International Working Conference on Dynamic Modelling of Information Systems*, Noordwijkerhout, The Netherlands, 1990.

Dijkstra, E.,"Cooperating Sequential Processes", F. Genuys (ed), *Programming languages*, Academic Press, 1968, pp.43-112.

Dixon, J.R. *et al.*, "Business process reengineering: improving in new strategic directions", *California Management Review*, Summer 1994, pp.93-108.

Donselaar, K.H., *Material coordination under uncertainty*, Doctoral dissertation, Technical University Eindhoven, 1989.

Drucker, P.F., "The coming of the new organization", *Harvard Business Review*, Jan.-Feb. 1988, pp.45-53.

Dur, R.C.J., *Business Reengineering in information intensive organizations,* Doctoral dissertation, Delft University of Technology, 1992.

Eekels, J. and N.F.M. Roozenburg, *Inleiding Methodologie*, Collegediktaat bb3, Technische Universiteit Delft, 1988. (in Dutch)

Emery, J.C., *Organizational planning and control systems - Theory and technology*, The Macmillan Company, 1969.

Emery, J.C., *Management information systems - the critical strategic resource*, Oxford University Press, 1987.

Enkawa, T., "Total logistics concepts in CIM environment", *EDI Europe*, vol.2, no.1, 1992, pp.61-74.

Ernst, R.G., "Why automating isn't enough", *The Journal of Business Strategy*, May-June 1989, pp.38-42.

Euske, K.J., *Management control - Planning, control, measurement, and evaluation*, Addison-Wesley Publishing Company, 1984.

Findeisen, W. *et al.*, *Control and coordination in hierarchical systems*, John Wiley & Sons, 1980.

Galbraith, J., *Designing complex organizations*, Addison-Wesley, 1973.

Galbraith, J., *Organization design*, Addison-Wesley, 1977.

Gasparski, W., *Understanding design: the praxiological - systemic perspective*, Intersystems Publications, 1984.

George, K.D., C. Joll amd E.L. Lynk, *Industrial organization - Competition, growth and structural change*, Routledge, 1991.

Gerstein, M.S., *The technology connection - Strategic change in the information age*, Addison-Wesley, 1987.

Goor, A.R., "Fysieke distributie (een overzicht)", W. Monhemius (ed.), *Logistiek Management*, Kluwer, 1987, pp.81-97. (in Dutch)

Goor, A.R., "Value added logistics als valkuil of uitdaging", *Bedrijfskundig Vakblad*, October 1994, pp.11-15. (in Dutch)

Hall, R.H., *Organizations, Structure and Process*, Prentice Hall, Inc, 1972. (Secondary reference from A.H. Van de Ven *et al.*, "Frameworks for interorganizational analysis", Negandhi (ed) 1975, pp.19-38.)

Hammer, Reengineering work: don't automate, obliterate", *Harvard Business Review*, July-August, 1990.

Harrigan, K.R., *Strategic flexibility*, Lexington Books, 1985.

Heygate, R., "Accelerating front-line change", *The McKinsey Quarterly*, 1992, No.1, pp.134-147.

Heygate, R. and G. Brebach, "Corporate reengineering", *McKinsey Quaterly*, 1991, No.2, pp.44-55.

Hoebeke, L., "Measuring in organizations", *Journal of Applied Systems Analysis*, vol.17, 1990, pp.115-122.

Hofman, W.J., *EDI Handboek*, Tutein Nolthenius, 1989. (in Dutch)

Hofman, W.J., M.T.A.M. Elshout and L.J. Kersten, "Een modelmatige aanpak van EDI", *Informatie*, Vol.33, No.4, pp.230-244. (in Dutch)

Holt, A.W., "Coordination technology and Petri nets", G. Rozenberg (ed.), *Advances in Petri Nets 1985 - Lecture Notes in Computer Science*, No.222, pp.278-296.

Holt, A.W., "Diplans: a new language for the study and implementation of coordination", *ACM TOIS*, Vol.6, No.2, April 1988, pp.109-129.

Hoekstra, S. and J.H.J.M. Romme (eds.), *Op weg naar integrale logistieke structuren*, Kluwer, 1987. (in Dutch)

Houlihan, J.B., "International supply chain management:, International Journal of Physical Distribution and Materials Management, Vol.15, 1985, No.1, pp.22-38.

Huber, G.P., "A theory of the effects of advanced information technologies on organizational design, intelligence and decision making", *Academy of Management Review*, vol.15, 1990, no.1, pp.47-71.

Hulst, W .G.H. van and J.G.L.M. Willems, *Externe organisatie*, Stenfert Kroese, 1989.

Hutchinson, N.E., *An integrated appraoch to Logistics Management*, Prentice Hall, 1987.

INRO-TNO, *Spitsvondigheden, Kwantificeren logistieke trade off's/test PIT model*, INRO-TNO, Delft, 1994. (in Dutch)

Johansson, H.J., P. McHugh, A.J. Pendlebury and W.A. Wheeler III, *Business Process Reengineering - Breakpoint strategies for market dominance*, John Wiley & Sons, 1993.

Johnson, H. and R. Kaplan, *Relevance lost - The rise and fall of management accounting*, Harvard Business School Press, 1987.

Johnston, R. and P.R. Lawrence, "Beyond vertical integration - the rise of value adding partnerships", *Harvard Business Review*, July-August, 1988, pp. 94-101.

Jol, K., "ECT blijft kop van Jut voor woedende vervoerders", *Transport en Logistiek*, May 1993, pp 16-18. (in Dutch)

Jong, T.R.M. de and R. Kuik, "Organizing logistics for customers", *IFIP W.G. 5.7 Conference on Advances in Production Management Systems 90*, Dipoli, Espoo, Finland, 1990, pp. 188-195.

Jorde, T.M. and D.J. Teece, Competition and cooperation: striking the right balance", *California Management Review*, Spring 1989, pp.25-37.

Kaplan, A., *The conduct of inquiry - Methodology for behavioral science*, Chandler Publishing Co., 1964.

Kaplan, R.B. and L. Murdock, "Core process redesign", *The McKinsey Quarterly*, No.2, 1991, pp.27-43.

Kaplan, R.S., "One cost system isn't enough", *Harvard Business Review*, Jan.-Feb. 1988.

Kidder, T., *Among Schoolchildren*, Avon Books, 1989.

Kaufman, F., "Data systems that cross organizational boundaries", *Harvard Business Review*, January-February 1966, pp.141-145.

Klir, G., "Complexity: Some general observations", *Systems Research*, Vol.2, No.2, pp.131-140.

Klir, G.J., "The emergence of two-dimensional science in the information society", *Systems Research*, vol.2, no.1, 1985, pp.33-41.

Koomen, C.J., "The entropy of design: a study on the meaning of creativity", *IEEE Transactions on Systems, Man, and Cybernetics*, Vol.15, No.1, Jan-Feb 1985, pp.16-30.

Konsynski, B.R., "Thinking of linking: managerial perspectives on electronic linkages accross organizations", R.J. Streng *et al.* (eds.), *Scientific Research on EDI "Bringing Worlds Together"*, Samson Bedrijfs-Informatie, 1992, pp.87-113.

Kotarbinski, T., *Praxiology: An introduction to the sciences of efficient action*, Pergamon Press, 1965. (secondary reference from Gasparski 1984)

Kreuwels, C., *Externe logistieke integratie en EDI*, Doctoral dissertation, Technical University Eindhoven, Kluwer Techniek, 1993. (in Dutch)

Kumpe, T. and P.T. Bolwijn, "Manufacturing: the new case for vertical integration", *Harvard Business Review*, March-April 1988, pp.75-81.

Kuypers, G., *ABC van een onderzoeksopzet*, Dick Coutinho, Muiderberg, 1992 (5th ed.). (in Dutch)

Lakatos, I.,"Falsification and methodology of scientific research programmes", I.Lakatos and A. Musgrave (eds.), *Criticism and the growth of knowledge*, Cambridge University Press, Cambridge, 1970.

La Londe, B.J. and M.C. Cooper, *Partnerships in providing customer service: a third party perspective*, The Council of Logistics Management, 1991.

Larson, A., "Network dyads in entrepreneurial settings: a study of the governance of exchange relationships", *Administrative Science Quaterly*, 37 (1992), pp.76-104.

Leeuw, de A.C.J.,"The control paradigm as an aid for understanding and designing organizations", R. Trappl *et al.* (ed.), *Progress in cybernetics and systems research, Volume V*, Hemisphere Publishing Corporation, 1979.

Leeuw, de A.C.J., *Een boekje over bedrijfskundinge methodologie*, Van Gorcum, 1990. (in Dutch)

Lodge, G. and R. Walton, "The American corporation and its new relationships", *California Management Review*, Spring 1989, pp.9-24.

Luke, R.D., J.W. Begun and D.D. Pointer, "Quasi firms: strategic interorganizational forms in the health care industry", *Academy of Management Review*, Vol.14 (1989), No.1, pp.9-19.

Mackenzie, K.D., *Organizational design: The organizational audit and analysis technology*, Ablex Publishing Corporation, 1986.

Magee, J.F., *Modern logistics management*, Wiley, 1985.

Malone, *What is coordination theory?*, CISR Working paper No.182, Sloan School of Management, MIT, 1988.

Malone, T.W., J. Yates, and R.I. Benjamin, "Electronic markets and Electronic Hierarchies", *Communications of the ACM*, Vol.30, No.6, June 1987, pp.484-497.

Malone, T.W. and K. Crowston, *Toward an interdisciplinary theory of coordination*, MIT Working Paper CCS TR#120, SS WP#3294-91-MSA, April 1991.

Manheim, M., "Beyond the logistics pipeline: opportunities for competitive advantage", J. Cooper (ed.), *Logistics and Distribution Planning*, Kogan Page, 2nd ed., 1994, pp.62-97.

March, J.G. and H.A. Simon, *Organizations*, John Wiley & Sons, 1958.

Marett, C. B., "On the specification of interorganizational dimensions", *Sociology and Social Research*, 56 (1971), pp.83-99. (Secondary reference from Aldrich (1975).)

Mather, H., "Winning orders by better logistics", *Logistics Information Management*, Vol.6, No.5, 1993, pp.35-39.

Merton, R.K., *Social theory and social structure*, Revised and enlarged edition, Glencoe, Ill., The Free Press, 1957.

Mesarovic, M.D., D. Macko, and Y. Takahara, *Theory of hierarchical, multilevel, systems,* Academic Press, 1970.

Morgan, G., *Images of organizations*, Sage Publications, 1986.

Miles, R.E. and C.C. Snow, *Organization strategy, structure and process*, McGraw-Hill, 1978.

Miles, R.E., "Adapting to technology and competition: a new industrial relations system for the 21st century", *California Management Review*, Winter 1989, pp.9-28.

Ministry of Economic Affairs, "Diensten: strategische kracht in de waardeketen", *Reeks Diensten en Economie*, April 1991. (in Dutch)

Mintzberg, H., *The structuring of organizations,* Prentice Hall, Inc., 1979.

Mintzberg, H., "The structuring of organizations", J.B. Quinn, H. Mintzberg, and R.M. James (eds.), *The strategy process*, Prentice Hall International, Inc., 1988.

Mintzberg, H., D. Raisinghani and A. Theoret, "The structure of 'unstructured' decision processes", *Administrative Science Quaterly*, 21 (1976), pp.247-175.

Mitchell, M.A. *et al.*, "Symbiotic logistics", *The International Journal of Logistics Management*, Vol.3, No.2, 1992, pp.19-30.

Morley English, J. (ed.), *Cost-effectiveness - The economic evaluation of engineered systems*, John Wiley & Sons, Inc., 1968.

Mourits, M., *Logistics distribution design tools*, Unpublished paper, Technical University Delft, 1994.

Mowshowitz, A., *Virtual organization: the future with information technology*, Summary of Presentation, Instituto Italiano Per Gli Stdudi Filosofici, Napoli, January 23, 1987.

Munford, C., "MSS tests enter second phase", *Cargo Systems*, May 1989, pp.33-34.

Nachmias, C. and D. Nachmias, *Research Methods in the social sciences*, Edward Arnold, 1981.

Nadler, G., "An investigation of design methodology", *Management Science* 13 (1967), No. 10 (June), pp.642-655.

Nadler, G., "Systems methodology and design", *IEEE Transactions on Systems, Man, and Cybernetics*, Vol. SMC-15, No.6, Nov./Dec. 1985, pp.685-697.

Nagel, *The structure of science*, Hackett, 1979.

Nauta Lemke, H.R. *et al.*, *Frekwentieresponsies in de regeltechniek*, Universitaire Pers Rotterdam, 1968. (in Dutch)

Neelamkavil, F., *Computer simulation and modeling*, John Wiley & Sons, Chichester, 1987.

Negandhi, A.R. (ed), *Inter organization theory*, The Kent University State Press, 1975.

Normann, R. and R. Ramirez, "From value chain to value constellation: designing interactive strategy", *Harvard Business Review*, July-August 1993, pp.65-77.

Oien, Finn, *Quantitative concepts and definitions in organization theory*, Oslo Institute of Business Administration, Oslo, 1969.

Overbeek, A. van, "Lagere kosten door EDI in de toeleverketen van DAF", *B&id*, Feb.1992, pp.14-19. (in Dutch)

Parker, M.M. and R.J. Benson, *Information economics, Linking business performance to Information Technology*, Prentice-Hall, 1988.

PDI/CALS Centre, *PDI/CALS-Informatie technologie voor strategische samenwerking*, Brochure, Zoetermeer, 1994. (in Dutch)

Peirce, C.S., "Lessons of the history of science", P.P. Wiener, *Charles S. Peirce: selected writings*, Dover Publications Inc, 1958, pp. 227-260.

Perrow, C., *A framework for the comparitive analysis of organizations*, American Sociological Review, 32 (1967), pp.194-208.

Pine, B.J., B. Victor and A.C. Boynton, "Making mass customization work", *Harvard Business Review*, September-October 1993, pp.109-119.

Polman, E.H. and J.J.A. Kok, "Management en Computer Integrated Manufacturing - Eerst vereenvoudigen dan pas CIM", *Telecommagazine*, June 1991. (in Dutch)

Popper, K.R., *The logic of scientific discovery*, New York, Science editions, 1961.

Popper, K.R., *Objective knowledge*, Oxford University Press, 1972.

Powell, W.W., "Neither market, nor hierarchy: Network forms of organization", *Research in organizational behavior*, Vol.12, 1990, pp.295-336.

Provnan, K.G. and S. Skinner, "Interorganizational dependence and control as predictors of opportunism in dealer-supplier relations", *Academy of Management Journal*, Vol.32. No.1, pp.202-212.

Putnam, H., "The corroboration of theories", R. Boyd *et al.* (eds.), *The philosophy of science*, The MIT Press, 1992, pp.121-138.

Quinn, J.B., T.L. Doorley, and P.C. Paquette, "Beyond vertical integration: Services based strategies", *Harvard Business Review*, March-April 1990, pp.58-67.

Ramondt, J.J., A. Rhebergen, M. Reijnders, F.van Dijk, *Innovatieprocessen van ziekenfondsorganisaties*, RISBO/TAO-Onderzoekscentrum EUR, Rotterdam, January 1993. (in Dutch)

Raser, J.R., D.T. Campbell, and R.W. Chadwick, "Gaming and simulation for developing theory relevant to international relations", L. von Bertalanffy and A. Rapoport, *General Systems*, vol. XV, 1979, p.183-204.

Ribbers, P.M.A., *Planning en organisatie van de inkoopfunctie in de industriële onderneming*, Doctoral Dissertation, Tilburg University, 1980. (in Dutch)

Ribbers, P.M.A., "EDI als een organisatorisch en strategisch vraagstuk", *Informatie en Informatiebeleid*, Fall (9) 1991, No. 3, pp.42-47. (in Dutch)

Ritchey, T.,"Analysis and synthesis, On scientific method - based on a study by Bernard Riemann", *Systems Research*, Vol.8, 1991, No.4, pp.21-41.

Rockart, J.F. and J.E. Short, "IT in the 1990s: managing organizational interdependence", *Sloan Management Review*, Winter 1989, pp.7-17.

Rolstadas, A., P. Falster, J.C. Wortmann, *Esprit basic research action 3143 for factory of the future, Workpackage 2 Report, Design of the conceptual model*, January 1991.

Rose, J. and G. Sharman, "The redesign of logistics", *The McKinsey Quaterly*, Winter 1989, pp.29-43.

Rotemberg, & Saloner, "Interfirm competition and collaboration", M.S. Scott Morton (ed.), *The corporation of the 1990s - Information technology and organizational transformation*, Oxford University Press, 1991, pp.95-121.

Ruijgrok, C.J., *Vervoer met PIT*, Inaugural speech, Catholic University Brabant, Stenfert Kroese, 1991. (in Dutch)

Sandholm, T., "An implementation of the contract net protocol based on marginal cost calculations", *Proceedings of the eleventh national conference on artificial intelligence*, AAAI Press / The MIT press, 1993.

Schary, P.B., "Logistics organization and the information system", *The International Journal of Logistics Management*, Vol.2, 1991, No.2, pp.22-29.

Scott, C. and R. Westbrook, "New strategic tools for supply chain management", *The international Journal of Physical Distribution and Logistics Management*, Vol.21, 1991, No.1, pp.23-33.

Scott Morton, M.S. (ed.), *The corporation of the 1990s - Information technology and organizational transformation*, Oxford University Press, 1991.

Searle, J.R., *Speech acts - an essay in the philosophy of language*, Cambridge University Press, 1969.

Searle, J.R., *A taxonomy of illocutionary acts*, 1975.

Searle, J.R. and D. Vanderveken, *Foundations of illocutionary logic*, Cambridge University Press, 1985.

Seifriz, W., "Creative imagination and indeterminism", *Philosophy of science*, Vol. 10, January, 1943, No.1.

Shannon, C.E. and W. Weaver, *The mathematical theory of communication*, University of Illinois Press, 1949. (Fifth paper back edition, 1972)

Sheombar, H.S., "The strategic impact of EDI on logistical organization: towards a method for business redesign", A.J. Groen (ed.), *Proceedings of the National Doctoral Conference on Management Studies*, Ede, The Netherlands, 1990.

Sheombar, H.S. and R.W. Wagenaar, "The strategic impact of EDI on logistical organization - Towards a method for business redesign", J.Gricar (ed.), *Proceedings of the 4th EDI Conference*, Bled, Slovenia, 1991.

Sheombar, H.S., "EDI induced logistical reengineering - Towards a theory of logistical coordination and guidelines for design", R.J. Streng *et al.* (eds.), *Scientific Research on EDI "Bringing Worlds Together"*, Samson Bedrijfs-Informatie, 1992, pp.157-182.

Sheombar, H.S., "EDI-induced redesign of co-ordination in logistics", *International Journal of Physical Distribution & Logistics Management*, Vol.22, No.8, 1992 (M.A. Emmelhainz guest ed.)

Sheombar, H.S., "Understanding logistical coordination in dyads - A prerequisite for EDI induced redesign", Invited to submit for publication in *EDI Europe*, Vol.3, No.4/1993, pp. 347-368.

Sheombar, H.S., "Logistics coordination in dyads - Some theoretical foundations for EDI induced redesign", to appear in: *Journal of Organizational Computing* (forthcoming).

Sheombar, H.S. and R.L.M. Dodde, "Activity based costing in Transport", Submitted for publication in: *Kluwer Checklisten in Logistiek Management*.

Sheombar, H.S., V. Holst and J. Mantel, "Coordinatie en het herontwerpen van logistieke ketens - Een case in de glasgroente sector", *B&id*, Vol.7, No.5, September 1995, pp.7-11. (in Dutch)

Short, J.E. and N. Venkatraman, "Beyond business process redesign: redefining Baxter's Business Network", *Sloan Management Review*, Fall 1992, pp.7-21.

Silver, E.A. and R. Peterson, *Decision systems for inventory management and production planning*, John Wiley & Sons, 1985.

Simon, H.A., *The new science of management decision*, Prentice-Hall, 1977.

Simon, H.A., *The science of the artificial*, MIT Press, 1981.

Stamper, R., *Information in business and adminstrative systems*, B.T. Batsford, 1973.

Stalk, G., "Time - the next source of competitive advantage", *Harvard Business Review*, July-August, 1988, pp.41-51.

Sterling, J.U. and D.M. Lambert, "A methodology for assessing logistics operating systems", *IJPD & MM*, Vol.15, No.6, 1985.

Streng, R.A.G.J., *Dynamic modelling to assess the value of Electronic Data Interchange*, Doctoral dissertation, Delft University of Technology, 1993.

Stuckey, J. and D. White, "When and when *not* to vertically integrate", *The McKinsey Quaterly*, 1993, No. 3, pp.3-27.

Stuckey, J. and D. White, "When and when *not* to vertically integrate", *Sloan Management Review*, Spring 1993, pp.71-83.

Suomi, R., *Assessing the feasibility of inter-organizational information systems on the basis of the transaction cost approach*, Doctoral dissertation, Turku School of Business Administration, Turku, Finland, 1990.

Swarte, J., *Activity Based Management voor het transportproces - De ontwikkeling van een adviesprodukt om de toegevoegde waarde van ABM voor het transportproces te meten*, Masters Thesis Rijksuniversiteit Groningen / Coopers & Lybrand, 1995.

Thompson, J.D., *Organizations in action*, McGraw-Hill, 1967.

Thorelli, H.B., "Organizational Theory: an ecological view", *Proceedings of the Academy of Management*, 1967, pp.66-84. (Secondary reference from A.R. Neghandhi, "Interorganization theory: introduction and overview", Neghandhi (ed.), 1975, pp.1-15.

Towill, D.R., M.M. Naim and J. Wikner, "Industrial dynamic simulation models in the design of supply chains", *The international Journal of Physical Distribution and Logistics Management*, Vol.22, 1992, No.5, pp.3-13.

Turney, P., "What an activity-based cost model looks like", W.G. Lamont (ed), *Emerging practices in cost management*, Research Institute of America Inc., 1993.

Van De Ven, A.H., D.C. Emmettt and R. Koenig, "Frameworks for interoganizational analysis", Neghandhi (ed.), 1975, pp.19-38.

Van de Ven, A.W. and D.L. Ferry, *Measuring and assessing organizations*, John Wiley & Sons, 1980.

Veld, J. In 't, *Analyse van organisatie problemen*, Stenfert Kroese, (5th edition) 1988. (in Dutch)

Venkatraman, N., "IT-induced business reconfiguration", M.S. Scott Morton (ed.), 1991, pp.122-158.

Venkatramen, N. and A. Zaheer, "Electronic integration and strategic advantage: a quasi experimental study in the insurance industry", *Information systems research*, Vol.1, No.4, December, 1990.

Vermunt, A.J.M., *Wegen naar logistieke dienstverlening*, Doctoral dissertation, Katholieke Universiteit Brabant, 1993. (in Dutch)

Yin, R.K., *Case study research: design and methods*, Sage Publications, 1989.

Vervest, P.H.M., *Communiceren, niet informatiseren - Over het adhoc organiseren van de waardeketen*, Inaugural speech, Erasmus University Rotterdam, 1994.

Volberda, H.W., *Organizational flexibility: change and preservation - A flexibility audit and redesign method*, Doctoral Dissertation Rijksuniversiteit Groningen, Wolters Noordhoff, 1992.

Wagenaar, R.W., "Business network redesign: lessons from the Port of Rotterdam simulation game", J. Gricar *et al.* (eds.), *Proceedings of the fifth international conference on EDI/IOS*, Bled Slovenia, 1992, pp.390-404.

Wierda, F.W., *Developing interorganizational information systems*, Doctoral dissertation, Technical University Delft, 1991.

Williamson, O.E., *Markets and Hierarchies - Analysis and antitrust implications*, The Free Press, 1975.

Williamson, O.E., *The economic institutions of capitalism*, The Free Press, 1985.

Williamson, O.E., Comparitive economic organization: the analysis of discrete structural alternatives, *Administrative Science Quaterly*, Vol.36, pp.269-296, 1991.

Williamson, O.E. (ed), *Organization Theory: From Chester Bernard to the present and beyond*, Oxford University Press, 1990.

Wijvekate, M.L., *Onderzoekmethoden*, Aula, 1992. (in Dutch)

Winograd, T. and F. Flores, *Understanding computers and cognition*, Addison-Wesley, 1986

Wortmann, J.C., "Meer-niveau afstemming in industriële toelevering", *Bedrijfskunde*, 66, 1994, no.4, pp.24-30. (in Dutch)

Wrigley, C.D., "The IOSGAME: Business simulation in information systems education", Montreal, Submitted for publication to *Simulation and Gaming*, 1993.

Zutphen, M.G., "De invloed van EDI op de coordinatie tussen organisaties", *Samenvattingen scripties afstudeerprijs EDI*, VEDI, 1991, pp.38-54. (in Dutch)

Zwaan, A.H. van der, *Organisatie-onderzoek*, Van Gorcum, 1990. (in Dutch)

Samenvatting

Logistieke coördinatie theorie - Een basis voor het gebruik van EDI in het operationele (her)ontwerp van bilaterale partnerships

Onderhavig proefschrift behandelt coördinatie, in het bijzonder logistieke coördinatie. Het is de bedoeling dat deze kennis over logistieke coördinatie een basis vormt voor (her)ontwerpers bij het inrichten van bilaterale partnershiprelaties waarbij elektronische gegevensuitwisseling (EDI, electronic data interchange) wordt gebruikt. Hierbij staan twee uitgangspunten centraal: ten eerste dat (her)ontwerpers dienen te worden ondersteund, en ten tweede dat logistieke coördinatie een centrale rol speelt bij het inrichten van Value Adding Partnerships (VAPs) en het gebruik van EDI daarin.

Een VAP is een stelsel van organisaties die nauw samenwerken teneinde de goederenstromen door hun bedrijven heen te besturen. Mede door de voorwaardenscheppende rol van informatie en telecommunicatie technologie (ITT) en de druk van klanten op de logistieke prestatie zijn VAPs sterk in opkomst. Idealiter wordt in een VAP de kanteling van een functionele naar een procesgeoriënteerde organisatie over de bedrijfsgrenzen heen doorgevoerd. Met name dit laatste aspect maakt van de inrichting van een VAP een ander soort project dan de bekende BPR (business process reengineering) projecten. In de literatuur over herontwerpen en coörinatie wordt enerzijds weinig aandacht besteed aan het herontwerpen van bedrijfsoverschrijdende processen, en anderzijds wordt er weinig tot geen aandacht besteed aan het toepassen van coördinatietheorie in (her)ontwerpprocessen.

Herontwerpers kunnen in een ontwerptraject op twee manieren worden ondersteund: met proceskennis over het inrichten en uitvoeren van het ontwerpproces, of met inhoudelijke kennis over het inrichten van het ontwerp zelf. Kennis van beide typen zijn in ontwikkeld waarbij het accent ligt op de inhoudelijke kennis, dus op de in hoofstuk 4 gepresenteerde theorie over logistieke coördinatie. In hoofdstuk 6 komt de ontwikkelde proceskennis aan de orde. Het gebruik van metaforen is behulpzaam gebleken bij het exploreren en vormgeven van de proceskennis. Naast literatuuronderzoek zijn empirische en hypothetische cases gebruikt om de kennis te ontwikkelen en te illustreren. De empirische cases betreffen de beschrijving van een partnerships tussen een stuwadoor en een rederij, en een partnership tussen een cosmetica producent en een logistieke dienstverlener. De derde case betreft een analyse van de mogelijkheden van partnerships tussen een inkooporganisatie van verpakkingsmateriaal enerzijds en haar producenten en transporteurs anderszijds.

Logistieke coördinatie

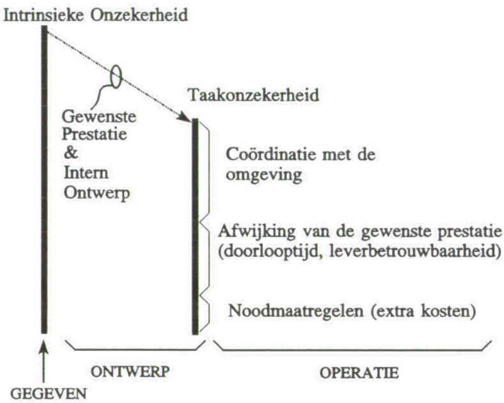
Organisaties dienen op logistiek gebied in essentie twee besturingsproblemen op te lossen, een capaciteits- en een materiaalbeschikbaarheidsprobleem, teneinde aan de logistieke doelstelling van de gewenste customer service tegen minimale kosten te voldoen. Bij het oplossen van het materiaal- en capaciteitsprobleem kunnen organisaties kiezen voor ontkoppeling in de vorm van buffers (buffervoorraden en/of buffercapaciteiten) of ze kunnen ervoor kiezen te coördineren met hun taakomgeving, i.c. toeleveranciers, dienstverleners, klanten. Dus kiezen voor het afstemmen van beslissingen teneinde de behoefte aan veiligheidsvoorraden en buffercapaciteiten te verminderen.

De essentie van (externe) coördinatie is onzekerheidsreductie bij het oplossen van (interne) besturingsproblemen. Door onzekerheid omtrent acties van actoren in de omgeving ontstaat de behoefte aan coördinatie en het effect van coördinatie is de reductie van onzekerheid. De theorie over coördinatie is opgezet aan de hand van twee organisaties die een partnership vormen, een dyadische of bilaterale VAP. In de levenscyclus van een VAP worden globaal twee fasen onderscheiden: de ontwerpfase waarin deelnemers uit beide organisaties om de tafel zitten om onder andere de processen en prestatiemaatstaven te ontwerpen, en de daarop volgende operationele fase waarbinnen zich de dagelijkse processen afspelen.

Logistieke coördinatie is gedefinieerd als de tijdige en bewuste afstemming van beslissingen in verschillende organisatorische eenheden gedurende het proces van het leveren van een dienst of produkt, waarbij de beslissingsvariabelen die betrekking hebben op de karakteristieken tijd, plaats, of de specificatie van het fysieke object worden afgestemd. Logistieke coördinatie tussen organisaties kan zich op twee niveaus afspelen: tussen de strategische decision making units (SDMU's) of tussen de operationele units (OU's). De SDMU is dat deel van een organisatie dat de processen, structuren, en produkt-markt-combinaties van een organisatie ontwerpt, terwijl de OU het operationele deel voorstelt waarbinnen de dagelijkse werkzaamheden worden uitgevoerd. In de ontwerpfase van een VAP kunnen ook logistieke variabelen op elkaar worden afgestemd, bijvoorbeeld door het aangeven van kaders voor leveringen, zoals minimale en maximale aantallen en levertijden. Deze coördinatie wordt ontwerpcoördinatie genoemd. Hierdoor wordt al voor een deel onzekerheidsreductie bereikt. Aangezien over het algemeen niet alle onzekerheid kan worden weggenomen in de ontwerpfase, zal in het algemeen ook de behoefte aan operationele coördinatie blijven bestaan.

De hoeveelheid onzekerheid die een organisatie heeft in de operationele fase, ongeacht of de organisatie deel uitmaakt van een VAP, is een ontwerpvariabele. Deze taakonzekerheid is een functie van de prestatie die de organisatie wenst te leveren en het bijbehorende ontwerp van de interne organisatie. Hoe hoger de gewenste prestatie, hoe groter de taakonzekerheid bij een bepaald intern ontwerp zal zijn, gegeven de aanwezigheid van intrinsieke onzekerheid, i.c. een onzekere omgeving. De taakonzekerheid vindt in de operationele fase zijn weerslag in coördinatie met de omgeving, in een afwijking van de gewenste prestatie, of in de uitvoering van noodmaatregelen (met bijbehorende extra kosten). De ontwerper dient doordrongen te zijn van de uitwisselbaarheid van de verschillende ontwerpvariabelen (zie figuur 1).

In een VAP wordt de taakonzekerheid van de deelnemende organisaties niet alleen bepaald door de onzekerheid omtrent acties van toeleveranciers en klanten van de VAP, maar ook door de onzekerheid die partners hebben omtrent elkaars acties. Deze vorm van onzekerheid die wordt veroorzaakt door de 'knip' tussen de twee organisaties in de VAP wordt grensonzekerheid genoemd. Met coördinatie binnen een VAP kan deze component van de taakonzekerheden van de partners worden aangepakt.



Figuur 1 - De operationele implicaties van de ontwerpvariabele taakonzekerheid

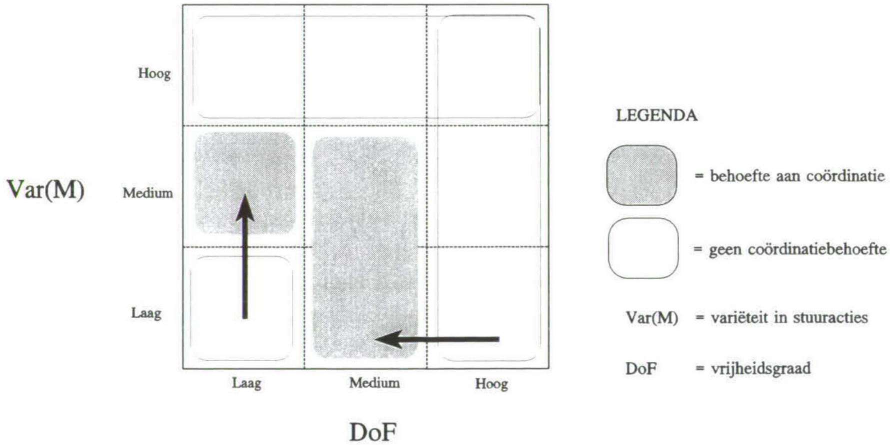
Bij de uitvoering van coördinatie worden twee aspecten onderscheiden: een besluitvormingsaspect en een communicatieaspect. Met het eerste aspect worden de afspraken omtrent het nemen van de verschillende logistieke beslissingen door de beide partners bedoeld, terwijl het communicatieaspect doelt op de informatie-uitwisselingen op grond waarvan de beslissingen worden genomen en de communicatie van beslissingsuitkomsten. Bij het ontwerpen van coördinatie worden dus afspraken gemaakt over beslissingsregels en over communicatiescenario's.

EDI en logistieke coördinatie

EDI is in de praktijk meer dan een communicatiemiddel. Bijvoorbeeld een middel om een handelsrelatie beter te leren kennen, een middel om klanten te binden, of een middel om het imago van de organisatie in de markt te vergroten. Als communicatiemiddel sec komt het verschil tussen EDI en traditionele communicatievormen neer op snelheid, betrouwbaarheid en kosten. Hierdoor maakt EDI het mogelijk om voorinformatie te versturen, om frequenties van berichtuitwisselingen te verhogen, en om gegevens tussen organisaties te delen. EDI draagt dus bij aan het communicatieaspect van coördinatie. Hierdoor kunnen beslissingen op basis van volledigere en actuelere informatie worden genomen en kunnen door de beschikbaarheid van meer en betere informatie eventueel andere, betere, beslissingsregels worden ontworpen.

In een VAP kan EDI dus door verbeterde coördinatie de grensonzekerheid reduceren. Bij het gebruik van EDI in VAPs kan de ontwerper derhalve twee strategieën volgen. Ten eerste kan de bestaande grensonzekerheid worden gereduceerd door verbeterde coördinatie. Ten tweede kan men de processen dusdanig inrichten en de gewenste prestatie dermate opvoeren dat de grensonzekerheid tussen de partners in de VAP omhoog gaat. De verhoogde grensonzekerheid kan vervolgens met coördinatie worden aangepakt.

Hoe kunnen nu bij het volgen van de tweede strategie nieuwe coördinatie-intensieve processen worden gevonden? Hiertoe zijn twee proceskarakteristieken gedefinieerd: de vrijheidsgraad (DoF) en de stuurvariëteit (Var(M)). De vrijheidsgraad geeft aan in hoeverre een actie gekozen in de ene organisatie de actieruimte in de andere organisatie beperkt. De stuurvariëteit geeft het beschikbare portfolio aan (effectieve) stuurmaatregelen weer. Hoe groter de stuurvariëteit hoe beter de organisatie kan inspelen op variëteit in de omgeving en in het fysieke proces van de organisatie. De relatie tussen beide karakteristieken en het nut van coördinatie is in onderstaande ontwerp-matrix weergegeven.



Figuur 2 - Ontwerprichtingen in de ontwerpmatrix

De verschillende aan EDI gerelateerde ontwerpmogelijkheden/niveaus zijn in onderstaande tabel weergegeven. In hoofdstuk 5 wordt elk van de ontwerpniveaus toegepast op een aantal hypothetische cases. Het doel van deze cases is de werkbaarheid van de in de tabel opgenomen richtlijnen aan te tonen. In de drie cases van hoofdstuk 7 worden de verschillende concepten geoperationaliseerd.

Tabel 1 - (Her)ontwerpen van VAPs

Verbeter categorie	Type	Voorbeeld	Commentaar
Implementeren van EDI	Efficiency	Verminderen van data entry personeel	Dit is geen herontwerp
Aanpassen aan de gereduceerde levertijd, verbeterde betrouwbaarheid, en de lagere kosten van EDI	Retuning	Herijking van veiligheidsvoorraden	
Verlagen van BU, door verbetering van het besluitvormingsaspect en het communicatieaspect	Break-through	Gebruik van echelon voorraadhoogtes in een distributiekanaal	EDI is slechts een deel van het ontwerp. Het delen van besluitvormingsregels is net zo belangrijk.
Verlagen van de vrijheidsgraad (DoF)	Break-through	Verlagen van buffervoorraden Vertrouwen op stipte, gespecificeerde, levertijden	Het realiseren van dit soort (her)ontwerpen in niet alleen van EDI afhankelijk
Verhogen van de variëteit in stuuracties Var(M)	Break-through	Verkleinen van produktie batches	Het realiseren van dit soort (her)ontwerpen in niet alleen van EDI afhankelijk

Proceskennis

Het beschouwen van organisaties in een VAP enerzijds als communicerende systemen gebruikmakend van communicatie theorie en anderzijds als communicerende actoren gebruikmakend van *speech act* theorie heeft een tweetal richtlijnen en bijbehorende hulpmiddelen opgeleverd voor het inrichten van het ontwerpproces (hoofdstuk 6).

Het eerste hulpmiddel partitioneert de communicatie tussen organisatie in drie niveaus: een technisch communicatie niveau (A), een semantisch en pragmatisch niveau (B), en een effectiviteits niveau (C). Dit laatste niveau heeft betrekking op de mate waarin communicatie resulteert in het gewenste/afgesproken gedrag van de communicerende partijen. Verstoringen kunnen de oorzaak zijn van het niet nakomen van afgesproken gedrag bij een bepaalde berichtuitwisseling. Organisaties in een VAP kunnen deels deze verstoringen voorspellen en daar speciale EDI berichten met bijbehorende procedures voor ontwikkelen. Dit wordt niveau-C communicatie genoemd. De richtlijn behorend bij dit communicatie partitionerings hulpmiddel is dat organisaties tijdens het ontwerpproces een strikt onderscheid behoren te maken tussen niveau-B en niveau-C communicatie, teneinde het proces beheersbaar te houden. Verder dient men een goed af te wegen hoever men gaat met het formaliseren van de niveau-C communicatie.

Door het gebruik van de metafoor "organisaties als communicerende actoren" is behalve een classificatie van logistieke berichten het tweede hulpmiddel voor het ontwerpproces naar voren gekomen. Het IR-toestandsdiagram (IR=interorganisatorische relatie) geeft de virtuele gedeelde toestand van de VAP processen weer. De IR-toestand op een bepaald moment geeft dus de toestand van een transactieobject weer zoals die wordt gezien door beide(!) organisaties. Het diagram is een hulpmiddel bij het ontwerpen van de communicatiescenarios. Samen dienen de ontwerpers van beide organisaties aan te geven welke toestanden kunnen voorkomen, welke transities zijn toegestaan, en hoe de transities zullen worden ondersteund. Dit laatste kan of met procedures of met berichtuitwisselingen. De richtlijn behorend bij het IR-toestandsdiagram is dat voor elke toegestane transitie een bericht dan wel procedure dient te worden ontworpen. Dit is essentieel om te voorkomen dat organisaties in de operationele fase verschillende percepties van de IR-toestand hebben en daardoor acties ondernemen die de andere organisatie als onjuist beschouwt.

De proceskennis is deels ontleend aan de ervaring opgedaan in de empirische cases van hoofdstuk 7, alwaar ook een illustratie van de richtlijnen en hulpmiddelen wordt gegeven. In hoofstuk 6 worden de proceskennis en de inhoudelijke kennis geïntegreerd in een methode voor het ontwerpen van VAPs. In de derde case van hoofdstuk 7 worden de eerste stappen van deze methode toegepast in het kader van een adviestraject.

Tot slot

In dit proefschrift wordt een bijdrage geleverd aan de coördinatie theorie doordat de theorie zich richt op *logistieke* coördinatie *tussen organisaties* en ontwikkeld is vanuit het standpunt van een *ontwerper*. De theorie wordt dan ook hanteerbaar gemaakt voor de organisatieontwerper door er inhoudelijke ontwerprichtlijnen uit te distilleren. Daarnaast worden er praktische hulpmiddelen en richtlijnen ter ondersteuning van het ontwerpproces gegeven, alsook een methode die de inhoudelijke ontwerpkennis integreert met de aangedragen procesmatige ontwerpkennis. De case studies op zich dragen ook bij aan de kennis van een organisatieontwerper. Gegeven het toenemende belang van de grensoverschrijding van onder andere logistieke processen mag worden gesteld dat de resultaten relevant zijn.

Verder onderzoek dient zich enerzijds te richten op een verdieping van de resultaten van dit onderzoek, zoals het toetsen van de theorie en het toepassen van de richtlijnen, en anderzijds op het verbreden van de problematiek van interorganisationele coördinatie. Hierbij valt te denken aan het meenemen van effecten van de machtsbalans, en het meenemen van de variabele "mens" zowel bij de inhoudelijke als de procesmatige kant van het ontwerpen van coördinatie.

Annexes

Annex 2.I - Some thoughts on obtaining and using knowledge

The research conducted is both scientific/analytical and applied/synthetic. The route towards the knowledge for design (the majority of our study) is predominantly deductive. The knowledge on design was obtained inductively. In this annex some elaboration of these notions is given.

2.I.1 Two routes towards knowledge

There are two conflicting schools of thought in the social sciences, the "Theory-Then-Research" and the "Research-Then-Theory" schools concerning the relation between (empirical) research and theory. According to the major proponent of the first approach, Karl Popper, scientific knowledge would best advance through the development of ideas (*conjectures*) and attempts to refute them through empirical research (*refutations*). Theories "... can only be reached by intuition, based upon something like an intellectual love for the objects of experience" (Popper 1961, p.32). Contrary to Popper, Robert Merton, a proponent of the "Research-Then-Theory" approach, argues that the role of research is not merely the verification and testing of theory. "Research plays an active role: it performs at least four major functions which help shape the development of theory. It initiates, it reformulated, it deflects, and it clarifies theory" (Merton 1957, p.103). The stages involved in both strategies are given in Figure 2.I.1.

<u>Theory-Then-Research</u>

1. Construction of an explicit theory or model
2. Selection of proposition for empirical investigation
3. Designing a research project
4. If the proposition is rejected modifications need to be made in the theory or design
5. If not rejected another proposition is chosen for investigation in order to improve the theory

<u>Research-Then-Theory</u>

1. Investigation of a phenomenon and delineating its attributes
2. Measurements of the attributes in a variety of situations
3. Analyze the resulting data for a systematic pattern of variation
4. If systematic patterns are discovered a theory is constructed

Figure 2.I.1 - Stages in research strategies (Nachmias & Nachmias 1981, p.48)

Closely related to this distinction in strategies is the distinction between inductive and deductive reasoning. *Induction* refers to the generalization of propositions from (a finite number of) particular empirical propositions (facts). This type of reasoning is applied in the Research-Then-Theory strategy. The opposite direction of reasoning, the derivation of particular propositions from generic ones is called *deduction*. These propositions

obtained by deduction, conjectures, can be tested in empirical investigation, hence the Theory-Than-Research strategy. Propositions and theory according to Popper, are always of a tentative
nature: we cannot verify theory, only falsify.

2.I.2 Synthetic and analytical research

Another distinction in types of research is that between *analytical* and *synthetic* research. The following description of the analytical and synthetic method of research is an abstract of the article by Ritchey (1991), an abstract which reflects the point of interest to our own research. (Quotations from the article are not marked as such explicitly.) The terms 'analysis' and 'synthesis' literally mean to 'loosen up' and 'to put together' respectively. These research methods can best be described using the systems concept.

A system is defined as an object consisting of components or elements which interact to produce an overall effect or *behavior*. Thus a system has a behavior or function when viewed from the outside, and elements which interact when the system 'black box' is opened. The elements and their interaction constitute the systems construction, i.e. its *process* and *structure*.[1]

There are two ways of obtaining knowledge about a system's functioning, whether it is artificial or natural. Either we can proceed from its construction and from there seek to determine the laws of the mutual interactions of its components as well as its response to external stimuli: effects from given causes - *synthesis*. Or we can begin with what the system accomplishes and then attempt to account for this: causes of given effects - *analysis*. The synthetic approach is therefore appropriate when the laws and principles governing a system's internal processes are known, but when we lack a detailed picture of how the system functions as a whole. The analytic approach is appropriate when a system's overall behavior is known, but when we do not have clear or certain knowledge about the system's internal processes or the principles governing these. Both approaches are depicted in the figure below.

Notice that simulation enables us to assess (simulate) the behavior of a synthesized system if the behavior of the components are known, while full knowledge of the laws and principles governing the interaction is lacking. Consider e.g. a system comprised of a server and customers arriving at a certain arrival rate. We can predict the behavior of the system, i.e. the average waiting time and the average queue length, using Little's Law. Or we can proceed by simulating a server and a customer arrival process and measure the average queue length and average waiting time. For this reason simulation is considered a powerful tool in the design or synthesis of complex systems.

[1] Notice how these properties of a system - effect, process, and structure - coincide with the phases in the adaptive cycle discussed in chapter one (see Figure 1.7).

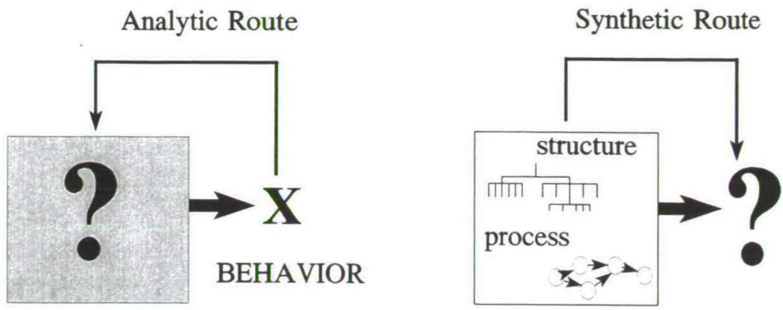


Figure 2.I.2 - The 'direction' of research

Within analytical research we must first analyze the system's tasks or problems it must solve. For each of these secondary tasks or problems we look at the systems structure to find in which manner these problems are solved. Thus, in our research we observe that organizations perform coordination, and we must look at the organizations themselves (we prefer not to use the term 'structure') to find out how they perform the coordination. The table below gives a summary of both methods.

Table 2.I.1 - Summary of the analytical and synthetic methods

Method	Applicability	Testable concept
Analysis	only overall behavior is known	Hypothesis (explanatory)
Synthesis	laws and principles of the parts are known	Guideline (prescriptive)

Research will be dominated by, but never limited to, one of the methods. In design and engineering we start with the box 'to be', model its components and relations, and from the constructed model predict the behavior, and compare it with the desired behavior. In the natural sciences, but also in the organizational scienes (see footnote 1), the behavior of the black box is the starting point of the research. We try to explain this behavior (either by the inductive or deductive approach), and construct models with which we can predict future behavior.

2.I.3 Scientific, applied, and operational research

Three types of research may be distinguished (Wijvekate 1992):

- *scientific* research, aims at finding knowledge of the world around us. This research answers questions e.g. regarding how things are, why they are, how they work (mechanisms)
- *applied* research, deals with applications of the knowledge of scientific research

- *operational* research, aims at finding a program of rules for achieving a desired practical state from a given practical state which is perceived as problematic by some problem owner.

These three types of research are related to Popper's three worlds as depicted in Figure 2.I.3. Describing these worlds can best be done in the words of Popper himself:

> " (...) the world consists of at least three ontologically distinct sub-worlds; or, as I shall say, there are three worlds: the first is the physical world or the world of physical states; the second is the mental world or the world of the mental states; and the third is the world of intelligibles, or of ideas in the objective sense; it is the world of possible objects of thought: the world of theories in themselves and their logical relations; of arguments in themselves; and of problem situations in themselves" (Popper 1979, p.154).

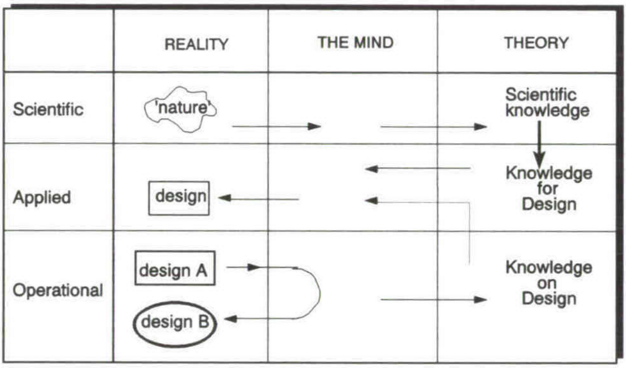


Figure 2.I.3 - Research types in terms of Popper's Three worlds

Figure 2.I.3 also shows the link to our model of organizational design (Figure 2.1) by naming the different theoretical outcomes of the research activities. Operational research is the same as clinical research. In our view clinical/operational research aims at producing only knowledge on design, and not knowledge for design. This may have something to do with our preference for deductive research.

Annex 5.I Analysis of the two stage inventory model

The following assumptions, which are common to (s,Q) control systems, hold for the processes in the VAP (from Silver & Peterson 1985 (S&P), pp.269-271).

(1) The (customer) demand is probalistic, but stationary (that is the average demand does not vary with time).

(2) The internal order of size Q_P is placed exactly as the inventory reaches s_P, which implies that customer orders are unit sized.

(3) If two of more internal orders are outstanding they are received in the same order as they were placed.

(4) The average level of back orders is small compared to the average level of on hand stock. The performance measure of the VAP, delivery reliability as defined above, will result in an operating procedure which will keep the number of backorders small, compared to the average stock.

(5) Forecast errors over a certain period are modeled by a normal distribution with no bias, and known standard deviation. The shape of the probability density function (pdf) of the errors is of importance in the determination of the safety factor. Since in the simulation study a Poisson demand function is used (negative exponential order inter arrival time), using the normal distribution is an approximation! Since we are interested in comparisons in performance (without and with EDI) the slight deviation in performance as defined by the safety factor resulting from this approximation is not relevant.

(6) The value of Q is assumed predetermined, and hence the decision variable s is calculated after Q has been determined.

(7) The costs of the control systems (v_i, A_i, r) do not depend on a specific value of s_i.

Additional assumptions are:

(8) Complete backordering: demand, when out of stock, is backordered. This holds for the Supplier as well as the Producer.

(9) The Supplier is fully dedicated to the Producer, and is the Producer's single source.

(10) The Producer does not accept partial shipments of the internal order.

Next the mathematical calculation of the process paramaters is described. First the derivation of the order quantities is given, followed by the calculation of the order points, and finally an assessment of the safety factors is given.

r = inventory carrying charge, in \$/\$/**unit time** (not year!!)
A_P = fixed cost per replenishment for the Producer, in \$
v_P = unit variable cost of item at the Producer, in \$/unit
A_S = fixed cost per replenishment for the Supplier, in \$
v_S = unit variable cost of item at the Supplier in \$/unit

Exhibit 5.I.1 - Notation used in the description of the VAP

- Order quantities

In the derivation of the order quantities deterministic demand is assumed, in which case it would not make sense to have Q_S anything other than an integer multiple of Q_P:

$$Q_S = n.Q_P$$

In the following determination of these quantities some coordination among them is achieved based on the cost of ordering and carrying (S&P.468).

step 1 Compute $n^* = \sqrt{[(A_S.v_P')/(A_P.v_S)]}$ with $v_P' = v_P\text{-}v_S$

step 2 Ascertain the integers n1 and n2 that surround n^*, $n1 < n^* < n2$

step 3 For $F(x) = [A_P + A_S/x].[x.v_S + v_P']$
If $F(n1) \leq F(n2)$ then $n = n1$ else $n = n2$

step 4 Evaluate $Q_P = \sqrt{[\ 2.(A_P + A_S/n).D\ /\ ((n.v_S + v_P')r)\ ]}$ (1)

step 5 Calculate $Q_S = n.Q_P$ (2)

- Reorder Points

The reorder point for the Producer is (see S&P.§7.8, or Anvari, 1992)

$$s_P = D.L + k_P.\sqrt{(L.\sigma_D^2 + D^2.\sigma_L^2)} \tag{3}$$

the second term of which, the safety stock (SS), accounts for the uncertainty in demand, σ_D, and the uncertainty in internal lead time, σ_L. The first term is called the lead time stock. The term $\sqrt{(L.\sigma_D^2 + D^2.\sigma_L^2)}$ represents the **intrinsic uncertainty** for the Producer. He can deal with it either by setting a non-zero safety factor k_P or by choosing a large batchsize Q_P (see eq.(5)), or a combination of both.

The reorder point for the Supplier is not directly based on a certain level of inventory, but on a certain amount of time, t_S, after his stock is depleted.

The assumption is that (<"t"> denotes the average of "t")

(11) <external supply lead time> is sufficiently smaller than the <internal inter order arrival time (Q_P/D)>

The following calculation of t_S is based on the observation that, under this assumption, for every nth order from the Producer, the stock of the Supplier becomes zero. He will not replenish immediately, but will estimate his point of ordering, T_{ORDER}, such that he just meets the (n+1)th order of the Producer (there is no point in carrying unnecessary stock). Thus

$$T_{ORDER} = T_{NTH\ ORDER} + t_S, \text{ with} \quad (4)$$

$$t_S = <x> - L_S - k_S.\sqrt{(\sigma_S^2 + \sigma_x^2)}$$

where
x = inter arrival time (iat.) of internal orders
$<x>$ = average iat. of internal orders, and
σ_x = standard deviation of the iat. of internal orders, and
$<x> = Q_P/D$ and
$\sigma_x = \sqrt{Q_P/D}$

- <u>The safety factors</u>

The safety factors represent the degree in which the control system copes with uncertainty. High safety factors will lead to high slack for dealing with uncertainty, but improved performance to the customers. The Producer's safety factor, k_P, is determined on the basis of the percentage of customers, P_2, which are to be delivered from the shelf. Given this percentage the corresponding (maximum) delivery reliability can be determined approximately (not accounting for possible stockouts at the Supplier).

For a percentage P_2 the safety factor can be approximated (see assumption (5)) by, S&P.eq.(7.24)

$$G_u(k_P) = [Q_P/\sqrt{(L.\sigma_D^2 + D^2.\sigma_L^2)}].(1-P_2) \quad (5)$$

in which $G_u(x)$ represents the number of orders to arrive in excess of x orders, assuming a standard normal (or Gaussian) demand distribution (that is with mean 0 and standard deviation 1).

For the safety factor of the Supplier we use the percentage of occasions that the Supplier cannot deliver immediately when his stock is depleted, P_1, which is every n internal orders. Notice that the overall percentage of prompt delivery is higher. Again using the approximation by the normal distribution, we can determine the safety factor k_S by, S&P.eq.(7.23)

$$p_{u\geq}(k_S) = 1 - P_1 \tag{6}$$

in which $p_{u\geq}(k)$ represents the probability that a variable with a Normal(0,1) distribution takes on a value of k or larger.

- Process values

The process values for t_S, Q_P, s_P, and Q_S used in the illustration are not calculated by for particular values for v_S, A_S, v_P, A_P, and r, but are chosen and the performance is evaluated by means of simulation. This appendix merely provides the reader with the insight needed to understand the description given in § 5.3.

Annex 5.II A blueprint specified in PSL.

For a full description of the process specification language (PSL) see Chin A Lien (1993).

```
BLUEPRINT INFO
  Process: Supplier - Producer VAP
  This blueprint will be used to demonstrate two rules.
  Rule II: higher message frequency
  Rule I : sharing information
  This version   c7.psl   is NOT shared variable
END

GLOBAL DATA
  Integer Qp, Qs, n, sP, ts, Lsfixed, Lfixed;
  Integer Inv, InvS;
END

IMPERATIVE
  Qp := 80;
  n:=2;
  Qs := n*Qp;
  Inv := Qp;
  InvS := n*Qp;
  ! zie ook initialisaties van de goods;
  ts := 170;  !
  sp := 63;   !
  LsFixed := 400;

  !Outtext("sp := "); !Outimage; !sp:= inint;
  !Outtext("ts := "); !Outimage; !ts:= inint;
END

UTILITY
WRITE PROCEDURE FOR
Level [Key : INTEGER [5], Level_P : INTEGER[10], Level_S : INTEGER[10]]

DISTRIBUTION L : NORMAL [280, 100]
DISTRIBUTION M : NORMAL [50, 5]
DISTRIBUTION Ls : NORMAL [200, 80]
END

!Notice the separate distribution M for message lead time

PROCESS
Vap ACTIVATES Accept WHENEVER Cust_Order
END

EVENT
Cust_Order [OrderNr : INTEGER]
END

RANDOM GENERATOR FOR Cust_Order
TRIGGERTIME DISTRIBUTION : NEGEXP [0.2]
INPUT [OrderNr : UNIQUE [0]]

TRIGGER
I_order [I_OrderNr : INTEGER]
S_order
delnot
Sdelnot
dum1
Repl
Del [OrderNr : INTEGER]
SDel [I_OrderNr : INTEGER]
```

```
Check
Dum [I_OrderNr : INTEGER]
Delivered [OrderNr: INTEGER]
END

DATABASE
Bo [OrderNr : INTEGER, Time : INTEGER]
BoS [I_OrderNr : INTEGER, Time : INTEGER]
END

PHYSICAL INFRASTRUCTURE
Ext
Sup CAP 300
Prod CAP 200
Intransp
END

!Physical infrastructure used to measure ave. inventories

GOOD
wdgts NAME wdgts LOCATION Ext
wdgts NAME sw QTY 334 UNIT 216 LOCATION Sup
wdgts NAME pw QTY 167 UNIT 108 LOCATION Prod
END

CARRIER
Truck NAME truck LOCATION Sup
END


!-------------------------- The Producer ----------------------------


IAS TASK Accept
TRIGGERED BY [Cust_order]
BODY
  Boolean Aux, Aux2;
  If Inv > 0 then Aux := true else
  Begin
       Aux := false;
       WriteBo (Tr1.OrderNr, Time);
  End;
  StartLeadTime ("CustLdt", "Cust_Order#", Tr1.OrderNr);
  Inv:= Inv - 1;
  If Inv = sP then Aux2:= true else Aux2:= false;
END
IF (Aux) THEN SEND TRIGGER Del [Tr1.OrderNr] TO Deliver DELAY 0.0
IF (Aux2) THEN SEND TRIGGER Repl TO Order


IAS TASK Order
TRIGGERED BY [Repl]
DATA
   Integer I_OrderNr;
   I_OrderNr := 0;
END
BODY
  Integer aux;
  Parent QUA Order.I_Ordernr := Parent QUA Order.I_Ordernr + 1;
  Aux := Parent QUA Order.I_Ordernr;
  StartLeadTime ("Intldt", "Iorder#", Aux);
END
SEND TRIGGER I_ORDER [Aux] TO SAccept DELAY 0.0


IAS TASK Back
TRIGGERED BY [DelNot]
DATA
  !to clear previous data block;
END
BODY
```

```
  Boolean Aux;
  REF (BoRec) Ptr;

  ! Read all records in the database and send 'del' for each;
  If BoDb.empty then aux := true else
  begin
  while BoDb.first =/= none  do
  begin
   Ptr :- BoDb.first;
   SendTrigger (NEW del ("del", "Deliver", Dummy, Tag, Ptr.OrderNr),0);
   BoDB.first.out;
  end
  end;
END

GAS TASK Deliver
TRIGGERED BY [del]
BODY
  REF (LocationObject) LocPtr;

  ! Afboeken ivm utilization statistics;
  LocPtr :- Location ("Prod");
  LocPtr.ReleaseCap(1);

END
SEND TRIGGER Delivered [Tr1.OrderNr] TO Customer DELAY 30.0


GAS TASK Receive
TRIGGERED BY [dum]
BODY
   REF (LocationObject) LocPtr;

   Inv := Inv + Qp;
   LocPtr :- Location ("Prod");
   LocPtr.AcquireCap (Qp);
   !Plaats goederen op Prod;

   EndLeadTime ("Intldt", Tr1.I_OrderNr);
END
SEND TRIGGER delnot TO Back


!-------------------------------- The Supplier -------------------------

IAS TASK SAccept
TRIGGERED BY [I_ORDER]
BODY
  Boolean Aux, aux2;
  If InvS > 0 then
  Begin
       Aux := true;
       InvS := InvS - Qp;
  end else
  Begin
       InvS := InvS - Qp;
       Aux := false;
       WriteBoS (Tr1.I_OrderNr, Time);
  End;
  If InvS = 0 then aux2 := true else Aux2 := false;
END
IF (Aux) THEN SEND TRIGGER Sdel [Tr1.I_OrderNr] TO SDeliver
IF (Aux2) THEN SEND TRIGGER Check TO Sorder


IAS TASK SOrder
TRIGGERED BY [check]
BODY
   Duration (ts);
END
SEND TRIGGER S_Order TO ExtSupplier
```

```
IAS TASK SBack
TRIGGERED BY [Sdelnot]
BODY
  Boolean Aux;
  REF (BoSRec) Ptr;

  ! Read all records in the database and send 'Sdel' for each;
  If BoSDb.empty then aux := true else
  begin
  while BoSDb.first =/= none  do
  begin
   Ptr :- BoSDb.first;
   SendTrigger (NEW Sdel ("Sdel", "SDeliver", Dummy, Tag, Ptr.I_OrderNr),0);
   BoSDB.first.out;
  end
  end;
END


GAS TASK SDeliver
TRIGGERED BY [Sdel]
BODY
  REF (LocationObject) LocPtr;

  !Plaats goederen intransp;
  LocPtr :- Location ("Sup");
  LocPtr.ReleaseCap (Qp);

  Duration (L.Sample);
END
SEND TRIGGER Dum [Tr1.I_OrderNr] TO Receive



GAS TASK SReceive
TRIGGERED BY [dum1]
BODY
  REF (LocationObject) LocPtr;

  InvS := InvS + Qs;
  LocPtr :- Location ("Sup");
  LocPtr.AcquireCap(Qs);
  !Plaats de goederen van Ext naar sup;

END
SEND TRIGGER Sdelnot TO SBack


!---------------------------- The Environment ---------------------------

TASK Customer
TRIGGERED BY [Delivered]
BODY
  Endleadtime ("CustLdt", Tr1.OrderNr);
END


TASK ExtSupplier
TRIGGERED BY [S_Order]
BODY
   !Creeer de goederen op locatie ext;
   Duration (Ls.Sample);
END
SEND TRIGGER Dum1 TO SReceive
```

Annex 6.I - A formal description of the IR state

A formal description of the IR state will be given by means of the finite-state machine (FSM) model. This description technique facilitates the design and specification of the business communication protocol between two OUs.[2]

The finite-state machine model. A state diagram is a (linear) directed graph made up of nodes (or vertices) and directed lines called edges (arcs). The nodes represent the states and the arcs represent transitions between states.

Definitions. The following definition of a FSM is restricted to the type of FSM that is used to represent the IR state diagram, i.e. we only have one input and one output variable at a specific point in time.(OUs send only one message at a particular point in time. Messages sent simultaneously are treated as though they were sent sequentially.) Apart from this restriction our IR state machine has the following common properties of a FSM.

1.a. A finite set of inputs. In our case this input is represented by the input variable α. The set of all m possible inputs is the input alphabet I, where

$$I = \{\alpha_1, \alpha_2, \ldots, \alpha_m\}$$

1.b. A finite set of procedures internal to the machine, which may trigger transitions in the absence of input. $\Pr = \{pr_1,\ pr_2, \ldots, pr_k\}$

2. A finite nonempty set S of (internal) states that the machine M can assume.

$$S = \{S_1, S_2, \ldots, S_p\}$$

3. The present state and the input uniquely determine the next state. The present state is a function of the **initial state** and the sequence of inputs or procedures applied thereafter.

4. A finite set of outputs. In our case the output is represented by the output variable β. The set of n possible outputs is denoted by the set O where

$$O = \{\beta_1, \beta_2, \ldots, \beta_n\}$$

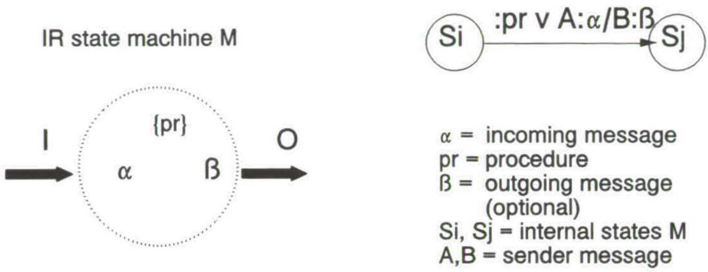
In case the output is determined by the internal state of M then the FSM is of the Moore type, and in case the output is determined by the input and the internal state of M the machine is of the Mealy type. The IR state machine is of the latter type. We thus define an IR state FSM as follows.

[2] Formal description techniques (FDTs) also allow for (mathematical) analysis (of correctness) of the specified protocol, e.g. whether they are complete, consistent, concise, unambiguous, and precise (ISO 8807). This is only possible if the technique is self-contained so that no informal knowledge is needed for its interpretation. Our use of the FSM FDT is augmented and no attempt will be made to provide the mathematical rigour to perform the types of analyses just mentioned. Since the state diagrams for logistical processes are small and can be analyzed 'manually' this is no drawback.

The FSM representation of the IR state is a 6-tuple
$<I, Pr, S, O, \delta, g>$ where $\delta{:}IxS \rightarrow S$; $\delta{:}PrxS \rightarrow S$; $g{:}IxS \rightarrow O$.

I is the set of possible messages which the input variable α can assume, Pr the set of rules and procedures belonging to the machine, S the set of states the IR can assume, and O is the set of output messages that the output variable ß can assume.

A graphical presentation of the IR state machine and of a transition are given in Figure 6.I.1.



(a) The IR state machine (b) A state transition

Figure 6.I.1 - Representation of the IR state machine

The state S_i of the IR state (machine) is a x-tuple, in which x is the number of attributes needed to specify the state. If a transition has no slash in its label, no output is generated for that transition. This can also be denoted by using "…/-" in the label. See the following examples (Figure 6.7).

Some remarks on FSMs

- In a completely specified FSM the number of edges emanating from every vertex is equal to the size of the input alphabet I, thus every input is specified for every state.
- If particular sequences of the input alphabet are never applied then the FSM would be incompletely specified.
- A FSM may have redundant internal states whereby their respective roles could be performed by other states.[3]

---

[3] In a state diagram representation of the IR state this is never the case since redundant states, imply that no messages/procedures have to be exchanged for those edges emanating and impinging on that state.

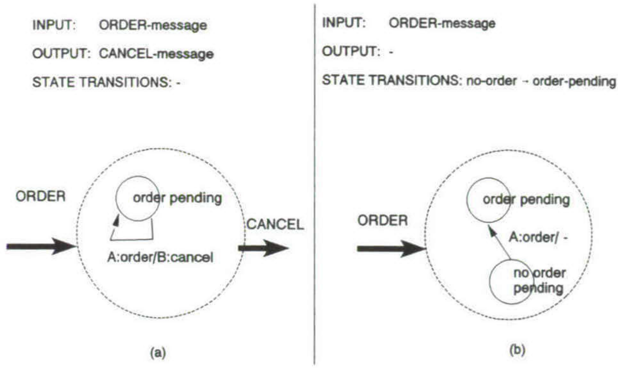


Figure 6.I.2 - Examples of output and transitions in the IR state FSM

Annex 7.I MESSAGE TABLE PHYSICAL DISTRIBUTION CASE

In this annex the business communication protocol between Beauty and PPL is described. The transmission medium and the timing of the message are stated. This protocol is the formal communication protocol as described in the Beauty PPL Operations Manual, which is part of the contract between the two organizations. (Formal here does not mean 'by formalized communication means').

Abbreviations:	c. = conditional;	mon = monday	A = Beauty
	e. = every	fri = friday	P = PPL

No.	From/ To	Name or Description	Medium	Timing	Comment
THE DELIVERY PROCESS					
1	A ▸ P	mutation base relations	e-mail	e. fri.	The customer base needed for the addresses.
2	A ▸ P	mutation base articles	e-mail	e. fri	All current articles within Beauty.
3	A ▸ P	base all CE* descr.	e-mail	e. fri	The consumer unit base is needed for the full description on the packing slip.
4	A ▸ P	Orders	e-mail	e. day: 16:30	Customer orders relayed to PPL for delivery
5	P ▸ A	Reports	e-mail	e. day: 8:00	Report on the orders delivered.
6	P ▸ A	ErrorList	fax	e. day: 8:00	This message reports on codes which are unknown to PPL (e.g. as a result of a desynchronized article base).
7	P ▸ A	Non-deliverable-articles	tel + fax	Ad hoc	This is a consequence of a difference in administrative inventory levels between Beauty and PPL. Beauty needs to block these articles from sales.
8	P ▸ A	Picking-Differences	tel + mail	Ad hoc	A consequence of differences in the physical and admin. inventory at PPL. This is necessary for Beauty to block these articles from sales.
9	A ▸ P	List pending orders	fax	Ad hoc	This is a provision for exception handling: every order must be accounted for in good business practice.

10	P ▸ A	Admin.Inventory LC	e-mail	e. mon am	Used for synchronization of the inventory levels.
11	A ▸ P	Rush order	e-mail	c. at 12:15	Customers can place rush order up till 12:00 hrs. These are picked the same day and hence delivered the next day.
12	A ▸ P	Rush order in mailbox	phone	c. at 12:15	Since there may not be rush orders every day, Beauty performs PPL of the fact that rush orders have been sent. An alternative is that always PPL checks the mailbox for rush orders.

THE REPLENISHMENT PROCESS

13	A ▸ P	Blocking/releasing goods	tel/fax	Ad hoc	It is possible (but not current practice) that there are goods in the LC which may not be delivered to the customers because they are blocked. This message is used to release the goods. The reverse is also possible, but would be rare.
14	A ▸ P	ShippingList	fax		Two or three trucks per day transport goods from Beauty to the LC. For every truck a ShippingList is sent.
15	P ▸ A	IntakeReport	tel		Also per truck.

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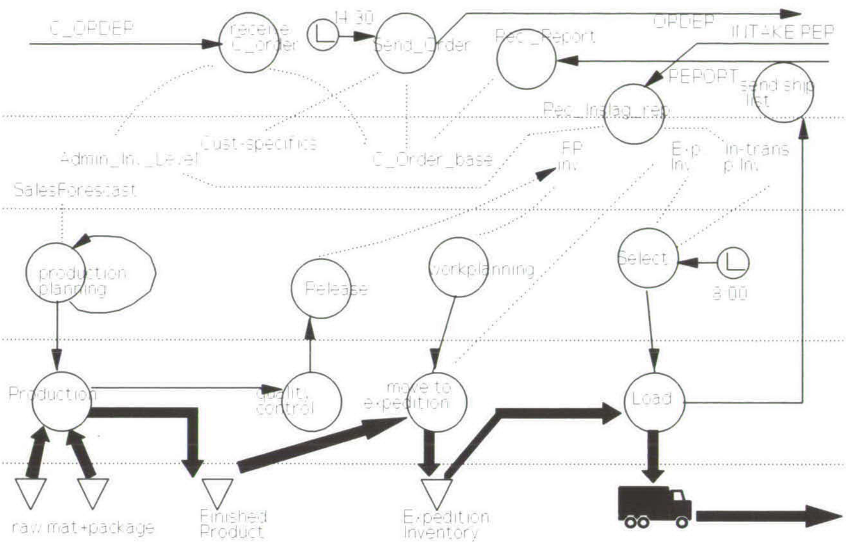
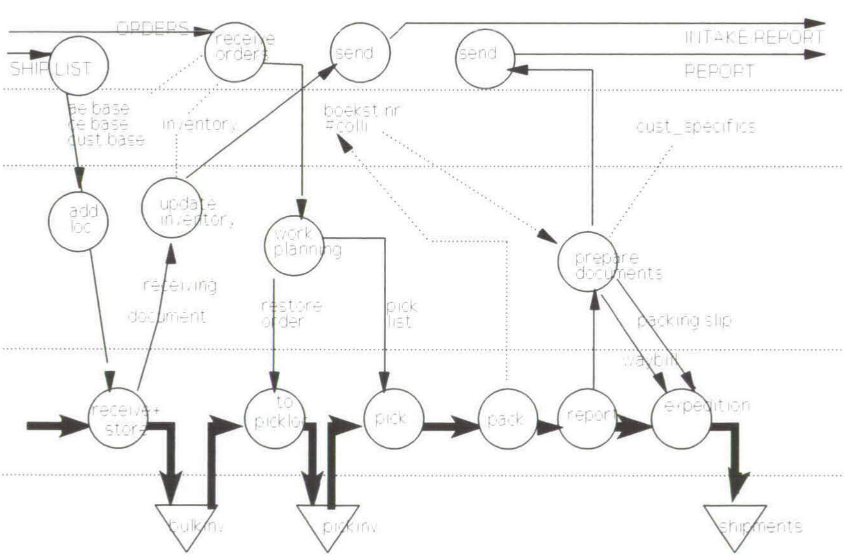
* CE = consumer unit (Du.: Consumenten Eenheid)

ANNEX 7.II PROCESS MODELS PHYSICAL DISTRIBUTION CASE

Process II within Beauty



Process II within PPL



About the book

Increasing emphasis on customer service and the enabling role of information- and telecommunications technology, in particular EDI, are transforming business processes: not only within but also across organizations. Dyadical Value Adding Partnerships (VAPs) are organizational arrangements in which two organizations manage their boundary crossing logistical processes jointly in order to meet customer requirements against minimal cost with maximum flexibility.

The set up and design of a VAP is critical to its success. Some of the issues that arise are: what shared procedures should govern the operational processes? What data should be shared and why? What messages should be exchanged and when? What is the required performance, both between partners and jointly to the customer of the VAP?

This book aims to support the designers of VAPs facing this type of issues. Members of a design team will benefit from the insight into the rationale and principles of logistics coordination. For understanding logistics coordination is understanding what a VAP is all about. Furthermore guidelines help to set the direction for EDI induced reengineering. In addition ready to use tools and guidelines that facilitate the design process are given. The material is illustrated in six case studies, three of which are real life cases.

About the author

Haydee Sheombar (1965) holds a Master's Degree in Electrical Engineering with a specialization in Telecommunications from the Delft University of Technology. She attended the Ph.D. programme in Business Administration at the Erasmus University Rotterdam. As a consultant of Coopers & Lybrand Management Consultants in the Netherlands Haydee is active in the area of external logistics, particularly in the design of (boundary crossing) business processes that make effective use of Information Technology and EDI.

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