HELSINKI UNIVERSITY OF TECHNOLOGY

Department of Industrial Engineering and Management

MARIA PAASIVAARA

Communication in Networked Product Development - A Case Study

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Instructor: Professor Reijo Sulonen

Supervisor: Professor Eila Järvenpää

Helsinki University of Technology **Abstract of the Licentiate's Thesis**

Author:	Maria Paasivaara
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Supervisor:	Professor Eila Järvenpää
Instructor:	Professor Reijo Sulonen

The purpose of this study was to explore the field of communication in company networks developing new products, an area which has not received much attention. Two case projects were chosen. Process simulation was used as the main research method, supported by other data collection methods, such as interviews.

The main communication patterns recognised were: project managers as gatekeepers, project meetings for change management and problem solving and emailed meeting memos for transmitting project status information. The main communication problems found were: a lack of common communication and information exchange mechanisms, an over reliance on key individuals, a lack of understanding of partners' information needs and information generation, a lack of direct contacts and non-working network-level document management.

The study suggests five means to improve networked communication: to create common communication patterns, operating procedures and principles for co-ordination and progress monitoring, to arrange a common team building meeting for the whole project team at the beginning of the project, and to introduce a common information system.

Based on both the literature and the case studies, a preliminary framework for communication in inter-company new product development was developed, consisting of: communication needs, communication requirements, media choice, communication process, elements disturbing communication, elements supporting communication, and established gains from networked new product development (NPD) projects.

Finally, the use of process simulation for data collection was evaluated. It seemed to be an effective and efficient method for collecting and partly validating rich data from several sources in one session, and also benefiting the participating companies.

Keywords: Company networks, communication, product development

Teknillinen Korkeakoulu **Lisensiaattityön tiivistelmä**

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Kommunikointia tuotekehitysverkostoissa ei ole tutkittu lähes lainkaan. Tämän tutkimuksen tavoitteena oli valottaa tätä vähälle huomiolle jäänyttä aluetta. Case tutkimuksen kohteeksi valittiin kaksi verkostoprojektia. Päätutkimusmenetelmänä käytettiin prosessin simulointia, jota tukivat muut menetelmät, kuten haastattelut.

Tärkeimmät case-projekteissa havaitut kommunikointitavat olivat: kommunikointi projektipäälliköiden kautta, projektipalaverien käyttö muutosten tekoon ja ongelmien ratkaisuun, sekä sähköpostilla toimitettujen kokousmuistioiden käyttö projektin tilannetietojen välittämiseen. Suurimmat löydetyt ongelmat olivat: yhteisten kommunikointi- ja tiedonvälitysmenetelmien puute, kommunikoinnin jääminen liiaksi projektipäälliköiden harteille, yhteistyökumppanin tiedon tarpeen ja tiedon tuottamisen heikko ymmärtäminen, suorien kontaktien puute sekä erityisesti verkostotasolla toimimaton dokumenttien hallinta.

Tutkimuksessa ehdotettiin, että yritysverkoston kommunikoinnin parantamiseksi tulisi verkoston yrityksille luoda yhteisiä käytäntöjä kommunikointiin, toimintatapoihin, koordinointiin ja edistymisen seurantaan, järjestää koko projektitiimille yhteinen tapaaminen projektin alussa sekä ottaa käyttöön verkoston yhteinen järjestelmä tiedon hallintaan.

Tutkimuksessa kehitettiin sekä kirjallisuuden että case-projektien tulosten avulla alustava viitekehys kommunikoinnista verkostoituneessa tuotekehityksessä. Viitekehys koostui kommunikointitarpeista, kommunikointivaatimuksista, median valinnasta, kommunikointiprosessista, kommunikointia häiritsevistä tekijöistä, kommunikointia tukevista tekijöistä sekä verkostoitumisella saavutetuista hyödyistä.

Tiedon keruuseen käytetyn prosessin simulointi menetelmän havaittiin olevan tehokas tapa sekä kerätä että validoida monipuolista, useista lähteistä kerättyä dataa. Lisäksi osallistuneet yritykset kokivat hyötyneensä simuloinneista.

Avainsanat: Yritys verkostot, kommunikointi, tuotekehitys

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Maria Paasivaara

Contents

1. Introduction

1.1 The background of the research

New products are increasingly developed in inter-company networks. There are several benefits arising from collaboration between firms, e.g., speeding up product development; obtaining resources, knowledge or technology; and sharing costs and risks. However, several studies have shown that the objectives of a collaboration are not always met (e.g. Bruce et al, 1995). Many of the problems leading to unsuccessful collaborative projects originate from a lack of communication and trust (Wynstra et al, 2001; Bruce et al, 1995). Moreover, previous communication research studying intra-organisational projects has shown that effective and efficient communication is a prerequisite for the success of a project (Moenaert et al, 2000) and that the better the product development team members are connected to each other and to key external parties, the more successful the project is going to be (Tushman & Katz, 1980).

This study hypotheses that successful communication is even more important for networked, inter-organisational product development projects than it is for intra-organisational projects, since these networked projects face barriers that are not so common in intra-organisational projects, such as geographical distance and differences in organisational culture and operating procedures. Arranging successful co-operation, and especially communication, in spite of these barriers, poses new challenges and brings out several questions: What are the needs for communication of networked new product development projects? How should communication be arranged? When should communication take place? What kind of information should be communicated? Who should communicate? How could this networked communication be supported?

Even though intra-organisational communication has received significant research attention, networked, inter-organisational communication almost leaves a gap in the literature, as will be shown in the literature review, in Chapter 2. To do its share of closing the gap, this study aims to explore the field of inter-organisational communication.

1.2 The ProDoku research project

This research was conducted in the TAI Research Center and Software Business and Engineering Institute at Helsinki University of Technology, as part of the ProDoku research project. ProDoku was financed by Tekes (The Finnish Technology Fund) and belonged to a larger research program called ProMuovi. The objectives of the ProMuovi program were to improve profitability of the Finnish plastics industry, whereas ProDoku concentrated especially on information and product data management issues.

1.3 The objectives and scope of the research

The objectives of this research are the following:

- To describe current communication patterns in networked, inter-organisational

product development projects.

- To find out what kind of communication problems these inter-organisational projects might have.
- To suggest managerial actions to enhance inter-organisational communication.

There are three research problems which will be further explained in Chapter 3.1. These research problems are:

- What kinds of communication patterns exist in inter-organisational product development projects?
- What kinds of communication problems do these inter-organisational projects have?
- How could communication in an inter-organisational network be enhanced and supported?

The main focus is on the first research problem, since the current state of communication should be well known before suggesting improvements. This study is limited to the two case projects chosen, because of the research project's scope and because we wanted to obtain a deeper understanding of these projects. Due to this limitation it is difficult to draw any general conclusions about networked communication based on the results obtained here. Instead, this research tries to explore and describe the field of networked communication, which has up to the present not been much researched. Besides the main research problems, this study also explores process simulation as a data collection method - earlier studies have mainly used it for process intervention purposes.

1.4 Terminology

This study explores communication in networked product development projects. The following sections defines the central terms used.

Communication includes all interaction and information exchange between parties. Examples include verbal, written and electronic information exchange, such as the transmission of documents.

In this study, the term *network* is used as a synonym for "inter-organisational". Some scholars use the term network also when discussing intra-organisational networks, e.g., when studying communication relationships between persons working within one organisation. When using the term network in a very broad sense, almost every relationship could be described as a network. For example, Nohria and Eccles (1992) define network as "the structure of ties among the actors in a social system". According to them these actors can be roles, persons, organisations, industries or nations, and ties may be based on conversation, affection, friendship, kinship, authority, economic exchange, information exchange, or anything else that could form a basis for a relationship. In another context, when dealing with electronic communication, the term network normally is used to refer to a computer network. In order not to confuse the reader, this study purposefully defines network relationship quite narrowly: it relates only to the collaboration relationship between two or more companies.

Networked product development refers to product development in which development

activities are performed jointly between two or more partners from separate organisations. The depth, breadth and timing of participation can vary.

1.5 The structure of the thesis

This work has five chapters: introduction, literature research, research design, results, and discussion. After each chapter, except the first one, the main points are reviewed in a summary.

Chapter 2 presents a literature review of past communication research in new product development. Earlier studies have mainly concentrated on intra-organisational communication, either between individuals or between functions. These studies have found e.g. correlation between communication efficiency and new product development lead-time. Also, communication in distributed projects has received attention, studies concentrating especially on the use of new electronic communication tools. However, inter-organisational communication has not been much studied. There are some studies about early supplier involvement, which bring out the importance and difficulty of networked communication. Moreover, recent studies about collaboration in virtual organisations state that the communication needs of these new forms of collaboration are not yet fully understood and more research is needed.

Chapter 3 concentrates on methodological issues. First, the research problems are described. Then, the research methods and case networks chosen are presented. This research used a case study method, which included several data collection methods, such as process simulation sessions, interviews and questionnaires. The main data collection method was process simulation, which has earlier been used mainly for process development purposes. As cases two networked product development projects were chosen, the first project consisted of four companies and the second was composed of two companies.

Chapter 4 presents results from the case studies. First, communication patterns, such as project managers as gatekeepers, project meeting for change management and problem solving, and meeting memos as the main source of information, are described. Second, a cross-case analysis compares the communication patterns and communication problems found in the cases. Third, actions enhancing communication are suggested. Fourth, inter-organisational communication is compared to intra-organisational communication and a framework for inter-organisational communication is suggested. Finally, experiences of the use of process simulation as a research method are discussed.

Chapter 5 concludes the research by discussing the results and compares them with earlier research. Also, this study is evaluated, its limitations are presented and topics for future research are suggested.

2. Literature research

This chapter discusses first organisational communication in general. The rest of the chapter presents literature about communication in new product development.

2.1 Organisational communication

Communication is essential to all organisations. It is self-evident for many, but it can be very difficult at the same time. Several fundamental questions can be asked: What is communication? Why do organisations communicate? Goldhaber (1993) defined organisational communication in the following way: *"Organisational communication is the process of creating and exchanging messages within a network of interdependent relationships to cope with environmental uncertainty."* According to Daft and Lengel (1986) organisations process information to reduce both uncertainty and equivocality. When the uncertainty faced by an organisation is high, acquiring and processing additional information is a solution. However, when equivocality is high, the field is messy and unclear and new data may even add uncertainty, because it may be confusing.

Organisational communication includes many elements. The following ten central elements are collected from literature. The most important is the *message* containing the communicated information. The r*eason* for communication expresses why parties communicate. Communication has at least two parties, a *sender* and a *receiver*, and their communication is based on a *relationship*. Communicators may be part of a communication *network*, where the *direction* of communication can be either upward, downward or horizontal (Goldhaber, 1993). The message is transmitted through communication *media*. Communication is affected by the organisational *environment*, and communication can be disturbed by *noise*.

There are several ways of classifying communication, e.g., by the forms or media. One division of organisational communication is into formal and informal communication. In formal communication, the message flows through official, prescribed channels, determined by the organisational hierarchy or job functions (Goldhaber, 1993). Informal communication, on the contrary, is based mainly on personal relationships. Goldhaber (1993) states that all communication that is not formal is informal. According to Krackhardt and Hanson (1993) informal networks can both help to accomplish tasks fast, but also sabotage good plans. Therefore, managers should recognise the existence of these networks (Krackhardt & Hanson, 1993), know their limitations and learn to use them (Goldhaber, 1993). When choosing a suitable communication media, media richness theory offers some advises. According to Daft and Lengel (1986) rich media, such as face-to-face communication is suitable for transmitting messages containing equivocality, while written media is better suitable for unequivocal messages.

Research methods that have been used to study organisational communication are e.g. structured observations and communication networks (Järvenpää & Immonen, 1996). When doing structured observations manager's communication behaviour is classified and observed. In communication network data is collected by questionnaires, interviews, observations or archival records. (Järvenpää & Immonen, 1996)

2.2 Communication literature in new product development

Figure 1. describes the field of communication research in new product development (NPD). In this figure new product development projects are grouped into four types according to the geographic and organisational dispersion of project team members. This study presumes that also communication in projects differs regarding these dimensions.

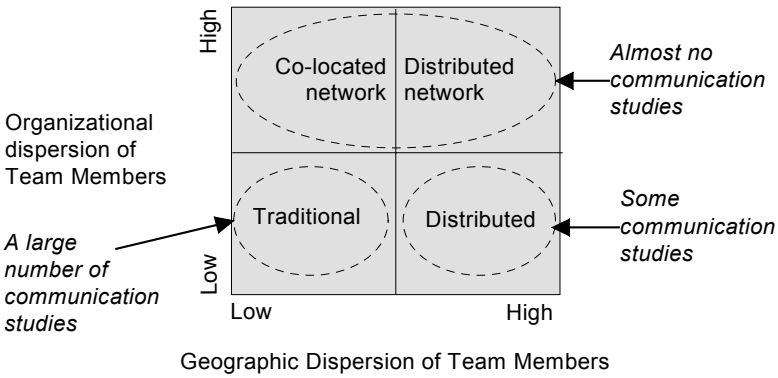


Figure 1. Past communication research of different types of projects. (Framework of project types modified from (Katzy et al. 2000))

Communication in traditional NPD projects (single firm, one location) has been studied carefully over the years. Both communication between individuals (e.g. Allen, 1984, 2000; Tushman & Katz, 1980) and between functions, like marketing, R&D and production, (e.g. Wheelwright & Clark, 1992; Soulder & Moenaert, 1992; Moenaert et al, 1994) has received attention. These studies show communication patterns and problems, which might also exist in networked product development, when departments, e.g. R&D and production, are situated in different companies.

Distributed NPD projects are carried out by a single firm, but across locations. Many studies of these distributed NPD projects have reported, how new information and communication technologies can support co-operation across locations. These studies, as well, can be compared to networked NPD (e.g. Boutellier et al, 1998; McDonough et al, 1999), because the geographical distance, a factor that hugely reduces communication (Allen, 2000), is almost always present in networked projects as well. Research about communication in intra-company NPD projects forms a solid foundation for communication studies in networked projects. However, compared to cross-functional interaction or distributed projects, communication across company borders poses additional difficulties, e.g., due to factors like lack of trust, differing ways of working, and legal issues.

Research studying communication in networked product development (across company borders) is still rare (Wynstra & ten Pierick, 2000). In Figure 1. networked projects are divided into two types: collocated network and distributed network. A collocated network could be for example a project with members from different companies. These team members move to work in joint premises during the project. Co-location could be also partial when, e.g. a supplier, sends an engineer to work on the customer's premises.

Having a resident engineer has actually become quite common nowadays, especially in Japan (Hines, 1994). We could not locate any suitable communication studies about these kinds of projects, therefore collocated projects will be left out of this literature study.

Distributed network include projects performed across both company borders and locations. In this study, when referring to networked or inter-company projects, we mean projects which are both distributed and networked. There is no danger of mixing them up with collocated networks, since collocated projects were omitted. In the literature communication in networked projects is dealt both in studies about early supplier involvement (e.g. Ragatz et al, 1997; Wynstra & ten Pierick, 2000) and virtual organisations (Wognum & Faber, 2001). Studies focusing on early supplier involvement are not exactly communication studies, but they also bring out the communication point of view. Some studies about virtual organisations, on the other hand, do concentrate on the communication aspect, but not on product development. Only one study (Wognum & Faber, 2001) was found about communication in virtual product development. This proves that literature about communication in networked product development projects is almost completely non-existent. The rest of this chapter will give a more detailed review about the literature on communication. A collection of writings, mainly articles, representative of each research stream, is presented.

2.3 Communication in traditional intra-organisational projects

Communication studies in traditional, intra-organisational projects have been divided here into two streams: communication between individuals and communication between functions. The first stream deals with team member's internal and external communication, and the second cross-functional integration and communication related to this. There is some overlap between these streams, since team members' external communication might also be directed towards other functional departments. Next, each of these streams is presented.

Table 1. Studies about communication in traditional intra-organisational projects.

COMMUNICATION RESEARCH IN "TRADITIONAL" INTRA-ORGANISATIONAL PROJECTS	
Communication between individuals	
Authors	**Main results**
Allen, 1984	A high level of both internal and external communication positively affects team performance. Increasing physical distance between communicating persons decreases the probability of communication almost exponentially.
Tushman & Katz, 1980, Katz & Tushman, 1981	Development projects (product or process) are effectively linked to external areas through gatekeepers, whereas research projects are more effectively linked to external areas through direct member contact.
Katz, 1982	Project group members that had been working for a long time together communicated less internally and externally than newer groups. This reduction in communication may also lead to a decrease in performance
Ancona & Caldwell, 1992a	The results indicate that a team's internal diversity affects performance negatively. Diversity brings creativity to problem solving and development, but it impedes implementation by decreasing the capability for teamwork. Greater functional diversity increases team members' external communication.

Ancona & Caldwell, 1992b	Research found four strategies that teams used for external communication: ambassadorial, task-co-ordination, scouting and isolationist. The type of external communication a team used determined performance, not the frequency of communication.
Moenaert & Caeldries, 1996	Relocating R&D personnel closer to each other did not increase the quantity of communication, but improved communication quality.
Morelli, Eppinger & Gulati, 1995; Sosa, Eppinger & Rowles, 2000	These studies provide a method to predict co-ordination-type communication between design groups of a complex product by analysing the architecture of the product to be developed. The ability to predict communication may allow managers to implement suitable organisational structures.
Communication between functions	
Authors	**Main results**
Moenaert & Souder, 1990	**R&D and marketing:** R&D appreciates written communication because of its higher credibility, while marketing prefers face-to-face communication due to its higher comprehensibility. To enhance communication between these functions trust, contextual information and formal communication rules are needed.
Souder & Moenaert, 1992	**R&D and marketing:** During the planning stage, R&D and marketing should exchange innovative information using informal channels. During the development stage the importance of co-ordinative information, exchanged between functional supervisors, increases.
Moenaert, Souder, DeMeyer & Deschoolmeester, 1994	**R&D and marketing:** Project formalisation and decentralisation, good inter-functional relations and role flexibility increase communication between R&D and marketing.
Griffin & Hauser, 1996	**R&D and marketing:** Based on the literature, the writers conclude that differences of personality and cultural, language, organisational and physical barriers between the departments prevents communication. They also suggest methods to achieve integration.
Maltz, Souder & Kumar, 2001	**R&D and marketing:** Inter-functional rivalry reduces R&D's use of information supplied by marketing and lowers the perceived quality of information transferred.
Wheelwright, Clark, 1992	**R&D and manufacturing:** Writers present four patterns of communication between upstream and downstream groups: the serial mode, early start in the dark, early involvement and integrated problem solving.
Nihtilä, 1999	**R&D and manufacturing:** The study identified four key integration mechanisms between these departments: standards, procedures and plans; milestone and design review practice; individual integrator; and cross-functional team.
Rochford & Rudelius, 1992	**R&D, marketing and manufacturing:** Quite often in the NPD process only one functional area, that has prime responsibility of the stage, contributes information to this stage. However, for several stages, obtaining information from more functional areas has a positive effect on new product performance.
Kahn, 1996	**R&D, marketing and manufacturing:** Collaboration between departments has a much stronger positive effect on product development performance than interaction. Actually, meetings and the exchange of documented information seem to have negative effects.
Kahn & McDonough, 1997	**R&D, marketing and manufacturing:** Co-location facilitates collaboration between R&D and marketing, but not between manufacturing and other departments. Co-location does not directly lead to improved performance, instead collaboration seems to have direct links to performance and satisfaction.

Pinto & Pinto, 1990	**Cross-functional team:** Teams with a high degree of co-operation used much more informal communication than low co-operation teams and their communication also engaged more on task related issues than resolving conflicts or other interpersonal difficulties.

2.3.1 Communication between individuals

This research stream deals with project team member's internal and external communications. Most studies find that increased internal and external communication affect a project's performance positively (e.g. Allen, 1984). However, not only the frequency of communication matters, but also the quality (Moenaert & Caeldries, 1996) and the type of communication (Ancona & Caldwell, 1992b). Internal communication is influenced e.g. by physical distance between team members (Allen, 1984), and the cohesiveness (Keller, 1986) and the homogeneity of a team (Ancona & Caldwell, 1992a; Bruce at al, 1995). External communication activities are facilitated by gatekeepers, (Allen, 1984; Tushman & Katz, 1980) and the functional diversity of a team (Ancona & Caldwell, 1992a). Also the type of the external interaction (Ancona & Caldwell, 1992b), and the tenure of a project group (Katz, 1982) should be paid attention to.

Internal communication

Allen (1984) studied the effect of physical distance on communication between two persons. His results indicated that the probability to communicate decrease almost exponentially as the distance increases. He discovered that for the probability of weekly communication the first thirty meters matter most. After that, probability did not differ much whether the distance was 100 meters or hundred kilometres. Allen's studies have affected e.g. the architecture of R&D offices and increased internal collocation. Moenaert and Caeldries (1996) studied collocation and got somewhat contrasting findings. Placing R&D professionals in closer proximity did not increase the amount of communication within a project team or between teams, instead, the quality of communication improved.

Ancona and Caldwell (1992a) studied the effects of team diversity on communication. They found that tenure homogeneity within a group increased the communication among team members, while functional diversity increased external communication. However, the overall effect of diversity on project performance was negative. The writers presumed that the reason for the negative performance might have been that the diverse groups bring ideas to problem solving, but fail in implementation, since their capability for team work is lower than in more homogeneous groups.

Also, the tenure of a project group affects communication according to Katz (1982). His study reveals that project performance is highest in projects with a mean project tenure[1] of the group members between two and four years. Thus, the project performance declines both with shorter and longer member tenures. At least a partial reason for this performance difference seemed to be communication behaviour. Members of long tenured groups interacted less often within their group and with external groups and probably became increasingly isolated from critical evaluation and outside knowledge. In the beginning, the performance of a new group increased, because of the positive effect of increased internal communication and fresh ideas from new members. The effect of long

[1] By project tenure Katz (1982) means how long the project members have been working together.

tenures of single engineers in the firm did not have a negative effect on communication if the engineers were not part of a long tenured group.

External communication

To develop successful products, product development projects need information outside their team, e.g. from other departments, and outside their company borders, e.g. market information and competitor information. There are several means to gather the information needed, one of them is using gatekeepers. Product development projects are effectively linked to external areas through gatekeepers according to Tushman and Katz (1980). Several studies have been written about them (e.g. Allen, 1984; Tushman & Katz, 1980; Katz, 1981). Gatekeepers are individuals who are strongly connected to both internal colleagues and external parties. They gather and understand outside information and translate it into terms which are understandable inside their own organisation. Besides that, they facilitate the extra-organisational communication of their colleagues. (Tushman & Katz, 1980). Gatekeepers are quite often first level technical supervisors, who have worked in their organisation for approximately six to eight years (Allen, 1984). The existence of gatekeepers had a very positive effect on effectiveness of locally defined development projects. Research projects, instead, were more effectively linked to external areas through direct member contacts (Tushman & Katz, 1980).

Ancona and Caldwell (1992b) found that it is not only the amount of external communication that determines a project's performance, but that the type of external communication of teams matters quite much, as well. The most successful teams that they studied used a comprehensive external communication strategy, which combined both ambassador and task-coordination behaviours. By ambassador behaviour they meant that a project group and especially a project leader had to "sell" the project to other persons outside the project, such as managers and other functions. By task-coordination behaviour Ancona and Caldwell meant project team's interactions with other functions, such as getting feedback and information from them and co-ordinating activities.

Predicting communication

Quite different from the research presented earlier are the studies about predicting technical communication based on product architecture (Morelli et al, 1995; Sosa et al, 2001). These writers have studied especially complex products such as aircraft engines that can be divided into subsystems. They suggest that where subsystems have design interfaces, there should also be communication between the teams designing different subsystems. The writers presume that their method improves the planning of development projects where the product architecture is known in advance.

2.3.2 Communication between organisational functions

In the past products were developed more in a serial mode, one department working at a time and then passing its results to the next department. Tight global competition, however, demanded shorter product development lead-times and better products, in terms of meeting customer requirements and easier manufacturing. Cross-functional integration and cross-functional teams aim to involve several functions more concurrently into the product development to meet these requirements. Also studies about concurrent

engineering, i.e., doing different phases of engineering work in parallel, deal with similar subjects. This new kind of involvement requires also more frequent communication and interaction between functions.

The term cross-functional integration is used very often, but its meaning is not self-evident. According to Kahn (1996) integration is a process including both interaction and collaboration. In another article Kahn and McDonough (1997) explain that collaboration means working together towards collective goals while having mutual understanding and sharing common vision and resources. Interaction, on the other hand, focuses on communication and information exchange (Kahn & McDonough, 1997). According to these definitions communication seems to have quite a central role in cross-functional integration.

Departments that are involved into the integration efforts are most often either R&D and marketing, or R&D and manufacturing or all three of these. Integration of R&D and marketing aims to bring R&D closer to the user needs. While R&D and manufacturing integration helps R&D to understand the manufacturing restrictions.

Communication between R&D and marketing

Communication between R&D and marketing has received quite much research attention. The barriers to communication between these functions are high, since these groups often have different educational backgrounds and differing thought worlds and they use different terms (Griffin & Hauser, 1996). Also, there are usually physical barriers separating the groups (Griffin & Hauser, 1996). Moreover, Maltz et al. (2001) found inter-functional rivalry, which, of course, lowered trust and the perceived quality of information transferred. Because of these barriers, trust between departments is very low, preventing efficient communication. Moenaert and Souder (1990) claim that trust can be developed through interaction and therefore suggest creating a formalised structure for communication that makes interaction mandatory.

R&D prefer written reports from marketing, since they perceive that written information is more thought out and based on facts. Marketers, on the other hand, prefer face-to-face communication, because it allows instantaneous feedback and enhances the comprehensibility of information (Moenaert & Souder, 1990). Even though the information may have been successfully transferred between the functions it may not be used. To use the information the person who received it needs to trust the sender, understand why that person gave him or her that information and receive also contextual information to see the relevance of the information to his or her work (e.g. why a particular customer requirement is important) (Moenaert & Souder, 1990).

Communication in different phases of a project seems to differ. During the planning stage more open communication is appreciated, even R&D might accept wild ideas. However, during the development stage more formalised communication is needed, since R&D does not want any unnecessary changes at that phase (Moenaert & Souder, 1990). During planning, emphasis is on innovative information, while in the development stage coordinative information is more important (Souder & Moenaert, 1992). Souder and Moenaert even suggest that centralised control is needed and therefore functional supervisors should transfer the coordinative information between functions.

Means to enhance communication include formal communication structures (Moenaert &

Souder, 1990), collocation (Kahn & McDonough, 1997) and role flexibility (Moenaert & Souder, 1994). Formalisation includes e.g. design review boards, milestone reports and scheduled meetings. Besides increasing formal communication, these formal structures also enhance informal communication. Role flexibility means that R&D personnel perform activities normally performed by marketing, or the other way round, and that way understand better the information requirements and information generation of the other party.

Communication between R&D and manufacturing

The two major questions that have been studied, in connection to cross-functional integration between R&D and manufacturing, are: 1) to which extent these activities can be done in parallel, and 2) how parallel work influences communication patterns. Loch and Terwiesch (1998) state that the gain from overlapping activities has to be weighted against rework that may result from starting the work with preliminary information. They also propose that communication will reduce the negative effect of rework.

Wheelwright and Clark (1992) have studied different modes of integration in terms of overlapping activities and communication patterns used. They present four possible modes of interaction between product development and manufacturing: the serial mode, early start in the dark, early involvement and integrated problem solving. In the serial mode a downstream group starts working when an upstream group finishes and information is transmitted in one batch. The "Early start in dark" mode means that downstream group has to start its work already before it gets information from the upstream group. Information is then transmitted in one batch after the upstream group has finished. In the early involvement mode upstream and downstream groups have intensive communication while the upstream group is still working. However, the downstream group's role is only to give feedback based on their earlier experience and they can start their own work only after the upstream group has finished. The last mode, integrated problem solving, involves the downstream group right from the beginning. The downstream group gets a flying start with their work and they can solve problems together based on their experience of really trying to implement the design.

Studies by Krishnan et al. (1997) and Loch and Terwiesch (1998) brought out the concepts of evolution and dependence (or sensitivity). These studies deal with overlapping activities in a more general sense, not explicitly stating which are the upstream and downstream groups. However, we believe that these groups can be R&D and manufacturing, as well as two R&D groups. Evolution describes how fast upstream information stabilises. When evolution is slow, big changes may happen near the end of the upstream phase. Dependence (or sensitivity) describes how big impact changes have on downstream activities. When dependence is low, large changes in upstream information can be easily adapted downstream. Loch and Terwiesch (1998) suggest that an expected communication frequency would increase over time when evolution is slow, and decrease with fast evolution. Moreover, when dependence between activities is high communication levels are also high according to Loch and Terwiesch.

Communication and co-operation between functions

Collaboration between departments seems to have a very strong positive effect on project performance according to Kahn (1996). Kahn also expected to find a similar relationship

between interaction and performance, but this hypothesis was not supported. Actually, meetings and the exchange of documented information seemed to have a slight negative effect on performance. Pinto and Pinto (1990) received somewhat contrasting results, when studying cross-functional communication in a medical R&D laboratory setting. Their findings indicate that high co-operation teams differed from low co-operation teams in their level of informal communication, i.e., high co-operation teams used the telephone more and had more informal discussions, while there were no significant differences in their use of other media. Pinto and Pinto also found differences in reasons for communicating. High co-operation teams engaged in task related communication, such as brainstorming, reviewing the progress and receiving feedback, whereas low co-operation teams spend more time on resolving interpersonal difficulties. The writers suggest that these findings may be due to higher trust between high co-operation teams' members. Therefore, they suggest that at the beginning of a project time should be devoted on team building activities to achieve a cohesive project team, and to enhance trust and co-operation. Moreover, Pinto and Pinto (1990) stress that communication patterns seem to have a strong connection to project success.

2.4 Communication in distributed intra-organisational projects

Distributed projects can take place inside a single country but across locations, or they can be internationally distributed. These international projects are quite often called global projects. All the studies referred to in this chapter deal with global projects. Besides the geographical dispersion of team members, that all distributed projects have, global projects have to manage also other communication barriers, e.g. cultural and language differences.

Table 2. Studies about communication in distributed intra-organisational projects.

COMMUNICATION RESEARCH IN "DISTRIBUTED / GLOBAL" INTRA-ORGANISATIONAL PROJECTS	
Authors	**Main results**
McDonough & Kahn, 1996	Higher performing global NPD teams use "hard technologies" like fax, email and phone calls much more than lower performing. However, "soft technologies", like encouraging collective goals, and promoting communication, trust and motivation, are seen to be even more important to the success of the project than hard technologies.
Hameri & Nihtilä, 1997	The World Wide Web provides an effective means especially for disseminating data in distributed product development projects. Project milestones play a coordinating role.
Boutellier, Gassmann, Macho & Roux, 1998	Application of information technology is vital for dispersed R&D teams, but for project to be successful also organisational components are needed, e.g. to create trust.
McDonough, Kahn & Griffin, 1999	Differences in country culture, country of origin, and geographic dispersion has an impact on the need for communicating information quickly, communicating rich information and communicating different volumes of information.
Moenaert, Caeldries, Lievens & Wauters, 2000	The requirements for effective and efficient communication in international product development teams are network transparency, knowledge codification, knowledge credibility, communication cost and secrecy.

McDonough, Kahn & Barczak, 2001	Global NPD teams experience more behavioural and project management challenges than collocated teams, due to the deterioration in their communications and difficulties in sustaining trust and developing interpersonal relationships.

Cultural differences

The importance of cultural differences to communication should be recognised. McDonough and Kahn (1996) state that the biggest problems in global new product development are cultural and social. Cultural differences have a significant effect on communication patterns in global teams. McDonough et al. (1999) list the following sources of differences arising from a cultural business context that have an impact on communication: approaches used to solve problems, means to communicate with leaders and decision-making practices. A problem solving approach can be e.g. a thorough analysis needing a lot of information, or a trial and error technique, which is possible with less information. In some cultures communication across functions may take place directly between engineers while some other cultures communicate hierarchically through leaders. Some cultures demand consensus for decision-making, others do not see any need for this.

Communication media

Geographical distance decreases possibilities for team members to meet face-to-face reducing the spontaneity of communication. It also reduces the amount of real time interactivity, because of time differences. Even though travel still plays a major role, it is increasingly supported by the use of modern information technology (Boutellier et al, 1998).

McDonough and Kahn (1996) studied the usage of information technology in global teams. They found in their case study that the higher performing teams used fax, email, phone calls, teleconferencing and postal mail to a much greater extent than the lower performing teams. The type of technology used did not have an impact on performance, only the frequency with which they were used had an impact. The best teams in their study normally used two main communication media frequently and others more seldom. Especially email, individual phone calls and teleconferencing were seen as important technologies for higher performing teams.

Email and other written media have an advantage when language is a barrier. Written communication is likely to be understood more completely than oral communication, since unknown words or phrases can be looked up (McDonough et al. 1999). McDonough, et al. (1999) found that the frequent use of phone calls was associated with higher performance. However, their results indicate that video conferencing would be negatively associated with performance. This surprising result might arise from difficulties in using the technology. Their study supported the use of several communication media suggesting that different media are suitable for different purposes. They list three communication needs: speed, richness and volume, and stress the importance of having available different communication mechanisms that can handle these needs. They suggest that different phases of the project might need different media. Moreover, different kinds of team's needs for information immediacy, richness, and volume might differ, requiring the use of a specific set of communication mechanisms.

Even though electronic communication is important for global teams, also face-to-face

contacts are needed to maintain a relationship. Electronic communication can prolong the times between face-to-face contacts, but cannot replace them (Boutellier et el, 1998). For electronic communication to be efficient, personal relationships and trust between employees are essential (Moenaert, et al, 2000). Trust and personal relationships are easier to establish through face-to-face meetings than merely using electronic media. Face-to-face contacts are also needed to keep team members interested, because when other team members are out of sight, it is easier to forget them and lose interest in the project (McDonough et al, 1999). Moreover, the only way to effectively deliver highly complex information, particularly across a product development team, is by holding face-to-face meetings, where communication can take place via multiple modes (McDonough, et al, 1999).

Face-to-face meetings are especially important at the beginning of a project to develop personal networks and to build up an atmosphere of trust (Boutellier et al, 1998). Some firms even arrange team-building meetings for one to two weeks at the beginning of a project (McDonough et al, 1999). The importance of that kind of socialization phase during a start-up has been clearly confirmed (Boutellier et al, 1998). Many interface problems that occur during the development phase may be explained by poor communication during the planning phase, e.g. because of not involving all the functions (Moenaert et al, 2000).

Co-ordination

Co-ordinating a distributed project is a challenge. Boutellier et al. (1998) suggest that project co-ordination and the exchange of technical information require media, which are characterised by information richness. Hameri and Nihtilä (1997) found that project milestones play an important role in co-ordinating the work in a distributed project. Also Moenaert et al. (2000) stress the importance of formal co-ordination mechanisms. They suggest that formal mechanisms, such as project review meetings, might be needed to exchange information at regular time intervals, since a lack of formalisation often creates problems in complex projects.

Communication requirements

Moenaert et al. (2000) suggest some requirements for communication in international product development teams. To establish effective communication, transparency of the communication network, knowledge codification and knowledge credibility are needed, whereas efficiency requirements are a low cost of communication and secrecy. Limited transparency may lead to problems in identifying the relevant persons to transfer information to or to obtain information from. Moreover, team members might have motivation problems, when they do not know why a particular assignment should be done. The writers found that strong leadership often increased the transparency of the communication network when team members used the team leader as the principal means for information diffusion. As the complexity of an international team increases, so does transparency have a tendency to decrease. Knowledge codification problems may arise from differences in language and culture, meaning both company subcultures and their own “languages” and national cultures and languages. Knowledge credibility problems, produced by the negative climate in cross-functional interfaces, may lead to the communicated information not being used. (Moenaert et al, 2000)

2.5 Communication in distributed inter-organisational projects

Two research streams that have studied communication in distributed inter-organisational projects will be presented next: early supplier involvement and virtual organisations.

Table 3. Studies about communication in distributed inter-organisational projects.

COMMUNICATION RESEARCH IN "DISTRIBUTED NETWORK" PROJECTS	
Early supplier involvement	
Authors	**Main results**
Ragaz, Handfield & Scannell, 1997	The study found that supplier participation in a buying company's project team was the largest differentiator between the most and the least successful supplier integration efforts, and direct, cross-functional, inter-company communication was the most widely used technique for integrating suppliers into NPD.
Wasti & Liker, 1997	When design involved technological uncertainties, Japanese firms involved suppliers more in product development and communicated with them more frequently. Competition in supplier market affected negatively both supplier involvement and the frequency of design related communication.
Wynstra & ten Pierick, 2000	Four types of supplier involvement were defined: strategic, critical, arm's-length and routine. Communication interfaces for these types were defined in terms of direction of information flow, communication media used, amount of communication, topics discussed and functions involved.
Croom, 2000	In early supplier involvement it is important that both structured and ad hoc processes of interaction are developed. A lack of ad hoc interaction may lead to failure.
Wynstra, van Weele & Weggemann, 2001	Supplier involvement holds great potential, but few companies seem to be able to realise the benefits. Problems resulted e.g. from lack of communication and trust.
Virtual organisation	
Author	**Main results**
Wognum & Faber, 2001	The concepts communication infrastructure and communication behaviour were introduced.

2.5.1 Early supplier involvement

Besides outsourcing production, it has become popular to outsource also part of the product development to the supplier producing the outsourced component. In these customer-supplier relationships product development may be performed mainly by the customer with early supplier involvement, by the supplier according to requirements set by the customer or as joint development. In early supplier involvement the supplier is involved in the product development project already during the design phase. Suppliers are involved in order to get a manufacturing point of view in that early design phase. The degree of early supplier involvement varies from supplier giving minor design suggestions to cases where the supplier has a part of the design responsibility. Also the phase of the product development process, when suppliers are taken in, varies. Ragatz et al. (1997) found in their survey that companies were planning to involve suppliers at an earlier stage in the future than before, and that they were also expecting deeper integration.

Studies about early supplier involvement cannot be directly categorised as communication studies. As they for example try to find out the forms of early supplier

involvement, its benefits and weaknesses, how early supplier involvement should be supported and what kind of effects it has on performance. However, many of those studies also bring out aspects of communication and its importance to project success. A lack of communication or wrong type of communication has often led to problems in early supplier involvement.

Benefits of early supplier involvement

Early supplier involvement has brought several benefits, improving both project effectiveness, in terms of product costs and quality, and project efficiency, in terms of development cost and time (Wynstra & ten Pierick, 2000; Wynstra et al. 2001; Ragaz et al, 1997). The largest part of product costs is set during the product development phase. Therefore, during that phase, a company should have access to all possible knowledge, also from the supplier's side. Later on, the designs are more difficult and expensive to change. During the design phase, suppliers can bring their design and manufacturing knowledge, resulting in better product designs and easier manufacturing. Moreover, suppliers can identify potential problems and solutions earlier, reducing both time and cost of design (Ragaz, et al, 1997). Besides early problem solving, supplier involvement helps product designers to understand manufacturing restrictions and to pay attention to them (Wasti & Liker, 1997).

Problems of early supplier involvement

Early supplier involvement does not always lead to success. The results can even be the opposite: increased development and product costs, lower product performance and longer than expected development time. Wynstra, et al. (2001) presume that the lack of positive results, that some studies suggest, does not imply that early supplier involvement is an inappropriate strategy, but that the expected results can not be achieved easily. According to Wynstra and ten Pierick (2000) supplier involvement may increase the complexity of managing development projects, because of an increased need for communication and co-ordination, especially in the situation of large projects using several suppliers. Collaborating with suppliers consumes both management time and money more than internal development.

Problems can rise from a resistance to sharing information. A customer company may not want to share proprietary information with suppliers, because of the fear that the supplier might reveal it intentionally or unintentionally to competitors. Also, for it might be difficult for a customer's engineers to accept ideas which come from suppliers. Besides resistance from the customer's side, also suppliers may be concerned about revealing their proprietary information or technologies. (Ragatz et al, 1997)

A lack of communication and trust may lead to unclear agreements and differing expectations, which complicate collaboration (Wynstra et al, 2001). Design outsourcing is very difficult, because of high technological uncertainty connected with design. Writing an accurate agreement or deciding correct price pose special challenges (Wasti & Liker, 1997). Moreover, problems arise if a customer fails to communicate to supplier correctly its requirements and expectations. Also, if a clear project plan and work-packages are missing or basic principles of collaboration have not been decided, differing interpretations may develop. If a customer does not have a well-defined product development process it is difficult for it to decide when and how suppliers should be

involved. (Wynstra et al. 2001)

Management practices to overcome problems

To overcome the problems mentioned above, managerial integration practices are needed. Ragatz et al. (1997) report that supplier membership on a customer company's project team was the largest differentiator between most and least successful supplier integration efforts. According to their results, this membership can be facilitated by direct cross-functional inter-company communication, shared education and training, common and linked information systems and selective collocation. Their results suggest that open and direct communication helps to identify and solve problems rapidly and shared training allows suppliers to get an insight into the customer company's internal processes. Linking information systems meant in their study mainly the use of EDI, email and CAD/CAM systems, whereas real-time linkages were not in widespread use yet, even though some respondents could see their implementation in the near future. Selective collocation is short-term collocation, which takes place during specific efforts, like prototype testing or problem solving. According to Ragatz et al. (1997) formal trust development practices were not used much, because trust is best fostered by performing according to expectations over longer time periods. Therefore, also all other management practices mentioned above help to build trust between companies.

Croom (2000) made a distinction between two competencies: operational and relational. Operational capabilities were task related, like design and manufacturing know-how, whereas relational capabilities included softer issues, such as communication, problem solving and relationship development. Croom stressed that these both capabilities were very important for product development performance, and that especially relational capabilities should not be forgotten.

Communication patterns and requirements identified

Forms of supplier involvement differ, sometimes very deep collaboration with frequent communication is needed, sometimes more distant relationship with minimal communication requirements is sufficient. Wynstra and ten Pierick (2000) suggested a classification of supplier involvement according to dimensions of development risk and the degree of development responsibility held by the supplier. They presumed that also communication needs differ according to these dimensions. Suggested involvement types were strategic, critical, arm's-length and routine development. In strategic involvement the supplier has high development responsibility and the development risk is high. Frequent, interactive communication through rich media, such as face-to-face communication, is recommended. In critical development, the development risk is still high, but the supplier's development responsibility is low. Limited communication is sufficient, because the supplier needs mainly just to comment on what is possible to manufacture and what is not. In arm's-length development, development risk is low and the supplier takes care of the development quite independently. Since the supplier needs to know exactly what the customer wants, the use of rich media is recommended. Finally, routine development carries low development risk and low design responsibility for the supplier. Minimal communication using media of low richness is enough. The purpose of Wynstra and ten Pierick (2000) was that from this classification companies could select an involvement type best suitable for their purposes and determine what kind of communication requirements the chosen collaboration type involves.

Communication might also differ in the different phases of a product development project. In the early phases of a product development project there is a high level of uncertainty and a supplier can not be given all the details at once. Also, designs may change during the project when new information becomes available. To reduce any uncertainties that a supplier faces, Wynstra and ten Pierick (2000) suggested that communication in the early phases of the product development should be frequent and interactive. Regular verbal communication is best suited for this situation. Furthermore, face-to-face meetings are, according to them, the easiest way to check whether both parties have understood each other correctly, because then both parties can explain what they mean. Wynstra and ten Pierick also stressed the importance of rapid communication lines, so that product development would not be delayed because of communication. By rapid lines, they meant direct contacts, e.g. between development engineers from both sides.

Croom (2000) has categorised interaction processes between supplier and customer. He found that interaction between companies contained both formal and ad hoc communication. Ad hoc communication is a less formal and reactive form of interaction. It appears e.g. when there are problems to solve or in social events. Croom stressed the importance of ad hoc communication, since he found that for effective supplier relationships ad hoc interaction was crucial, and a lack of it led quite often to problems and failures. Formal, more predetermined communication, uses channels such as team meetings and resident engineers. These formal communication channels can be described through standard operating procedures, whereas ad hoc communication poses a challenge. Officially ad hoc communication is quite often "handled" as if it did not exist, and therefore it is not supported either. Since ad hoc communication seems to be beneficial, it should also be supported.

2.5.2 Virtual organisations

The term virtual organisation has many definitions. All the definitions have at least some of the following elements: Virtual organisations are geographically, and maybe also culturally, dispersed, working across space, time and organisational boundaries. They communicate and co-ordinate their work through information technology, or electronic networks. The structure of virtual organisations is very flat, they are non-hierarchical and decentralised. They are temporary in nature, consisting of a group of people working towards common goals, and dispersing when the task has been completed. Besides all this, they are also very flexible, and can react quickly whenever the environment changes. A virtual organisation is like an amorphous web of connections changing constantly according to needs.

Different studies emphasise different qualities of virtual organisations, and none of the studies defines them with all these qualities. Actually, a definition with all these elements sounds more like an imaginary picture of the future and not the present reality. Do these kinds of organisations really exist? Kraut et al. (1999) stated that they had had difficulties to find virtual organisations that would fulfil their definition, leading them to reconsider the definition. Therefore, they suggested that virtuality would actually be a matter of degree. It can be viewed as a continuum, with almost all firms having at least some qualities of virtual organisations. Moreover, virtual organisations do not normally come into existence as perfect virtual organisations, instead, they slowly develop and grow

from more traditional organisations (Kraut et al, 1999).

This study sees virtual organisations as one kind of a distributed network. According to our definition, the term "distributed network" includes all projects that are geographically and organisationally dispersed. Most definitions of virtual organisations fulfil these requirements, even though some studies allow also intra-firm projects to be virtual. We believe that all networked product development projects could be called virtual projects as well. However, this study does not use the term virtual organisation, since the term does not have any established definition or use, and this leaves space for misunderstandings.

As mentioned above, it can be difficult to find real virtual organisations, however, it is even more difficult to find studies about these real virtual organisations. This study could locate only one article (Wognum & Faber, 2001) about communication in virtual product development projects. The rest of the articles, referred to here, study communication in different kinds of virtual organisations.

The structure of virtual organisations

Virtual organisations are expected to be more effective and efficient than traditional organisations, since they are very flexible and fast to respond. This flexibility is believed to result from their loose structure. The glue that holds a virtual organisation together is communication and personal relationships, not formal structures. However, there is not much empirical evidence about the structures of virtual organisations (Ahuja & Carley, 1999). Actually, Ahuja and Carley found, in their study of a research organisation, that even though the authority structure was very flat, the communication structure was somewhat hierarchical. The writers suggest that the communication structure should be aligned to the task characteristics: routine tasks need more hierarchical structure whereas complex tasks should be managed by promoting discussion and decentralised decision making.

Co-ordination in virtual organisations

The co-ordination of a virtual organisation poses a challenge. Traditional, more hierarchical organisations, base their co-ordination on standardisation and direct supervision. In a virtual context, supervision is expected to be costly, difficult and ineffective since employees are dispersed and co-ordination should take place between firms. Yet, virtual organisations probably need co-ordination more than traditional organisations to function effectively. Katzy et al. (2000) state that a team member in a virtual project needs to know exactly when, what and how something is being done by different members of the organisation. Wiesenfeld et al. (1999) add that co-ordination should help a team member to formulate reliable expectations about the behaviour of other team members. Even though the importance of co-ordination in virtual projects is recognised, very little is known about successful co-ordination practices (Katzy et al, 2000).

Earlier research (according to Wiesenfeld et al, 1999) suggested that virtual organisations should replace external controls with internal controls, such as motivation, trust and shared goals, and co-ordinate less through hierarchy and more through transaction (DeSanctis & Monge, 1999). Moreover, personal relationships, not only electronic

networks, might be needed (Kraut et al, 1999). Wiesenfeld, et al. (1999) found that organisational identification may help to ensure co-ordination. Organisational identification represents social and psychological ties that bind employees and an organisation. Wiesenfeld et al. stressed that communication would be needed to create and maintain organisational identification in a virtual context. Communication would strengthen member identification by helping to build a shared context and social presence. They suggested, that to create organisational identification, face-to-face communication should be preferred over email and phone calls, since face-to-face communication can also transmit social context cues. The created organisational identification could then be maintained through less rich communication media, particularly electronic communication was found to be important. They also stressed the importance of creating an organisational culture that encourages the use of on-line media to share information.

Kraut et al. (1999) studied the role of electronic networks and personal relationships in co-ordination. They found that when interpersonal relationships were used for co-ordination also the use of electronic co-ordination activities rose. These results indicate that electronic and personal co-ordination are not alternatives, but supportive means for co-ordination. Kraut et al. suggested that personal relationships are especially valuable when co-ordinating a complex process with non-routine transactions.

Communication in virtual organisations

DeSanctis and Monge (1999) stated that empirical research about communication in virtual organisations was almost non-existent, only a few studies have been done. Thus, the suggestions about efficient and effective communication principles in virtual organisations are based more on expectations than empirical facts. Communication in virtual organisations is expected to be rapid, customised and based on personal relationships and informal contacts (DeSanctis & Monge, 1999). The volume of communication in virtual organisations is presumed to be greater than in hierarchical organisations, since the structure is actually formed by two-way communication links between a great number of persons forming the organisation (Ahuja & Carley, 1999; DeSanctis & Monge, 1999).

Electronic communication is often seen not only as an important enabler of virtual organisations, but also as a necessity. However, electronic communication has also its negative sides: problem solving may be difficult and electronic communication may also affect negatively the understanding of a message, if contextual information is missing. Therefore, DeSanctis and Monge (1999) suggested that communicating parties should be provided rich contextual information in order to better understand the message and to create a deeper contact. Electronic communication never seems totally to replace traditional communication, instead, it complements other forms of communication and actually increases the total amount of communication. Face-to-face contacts seem to be a better and faster way to solve conflicts and create mutual understanding. Moreover, like Wiesenfeld et al. (1999) suggested, face-to-face communication might help to establish a relationship, which then can be maintained by electronic communication.

It is also possible to work virtually using only electronic media, like in the study by Jarvenpaa and Leidner (1998). They studied trust in global virtual teams. These teams, consisting of students, never met face-to-face and the only reasonable communication media they had were electronic. The results of their study suggested that the most

successful teams created quite a lot of transparency around each others tasks through communication: they told other team members what they were doing, or going to do, and forewarned others about when they would be absent in the future. Also, providing thorough feedback was important. Social communication, complementing task communication, helped these teams to build trust. Moreover, the results indicated that it was not only the quantity, but especially the quality and predictability of the communication that were critical for success. Therefore, it might be useful to provide guidelines on how often to communicate and enforce regular pattern of communication. Even though the electronic media can not easily transmit social context cues, this was not perceived only as being negative, as electronic media actually seemed to increase the perceived similarity among members, thus making cultural differences less noticeable.

2.6 Comparison of the research streams

The communication research streams presented earlier are compared in Table 4. in terms of key research interests, communication needs, communication requirements, communication barriers, communication enablers and communication media.

Table 4. Comparison of the research streams.

	TRADITIONAL		**DISTRIBUTED**	**DISTRIBUTED NETWORK**	
	Between individuals	**Between functions**		**Early supplier involvement**	**Virtual organisations**
Key research interests on communication	Frequency of communication. Physical distance. Gatekeepers.	Cross-functional integration mechanisms.	Overcoming the barriers of communication. Electronic communication media.	Co-ordination of a complex project Overcoming the barriers.	Co-ordination of virtual work. Electronic communication. Communication structure.
Communication needs	To get external information, ideas and feedback.	To co-ordinate work. To get input from other functions. To enable concurrency.	To co-ordinate work.	To co-ordinate work. To explain requirements to supplier.	To co-ordinate work. To build personal networks and trust.
Communication requirements	Informal contacts.	Understanding information, credibility and the timing of information.	Transparency of network, understanding cultural context.	Understanding received information.	Transparency of network, fast communication, informal contacts.
Communication barriers	Physical distance.	Physical distance, functional borders, different terminology and education, lack of trust.	Geographical distance, differences in culture, language and information systems, lack of transparency.	Resistance to sharing information across company borders, complexity of network.	A lack of trust, a lack of face-to-face contact.

Communication enablers	Short distance, cohesive and homogeneous team.	Co-location, trust, formal structures for communication, role flexibility.	Face-to-face meetings in the beginning, transparency of the network.	Direct contacts, frequent communication, linked information systems.	Frequent communication using both face-to-face and electronic media, personal networks.
Communication media	Face-to-face, phone calls.	Face-to-face for comprehensibility, written for credibility.	Face-to-face in the beginning, then electronic.	Face-to-face to explain requirements.	Electronic mainly. Face-to-face to build trust and create contacts.

2.7 Summary and conclusions

This chapter presented a literature review about communication in new product development. Communication in networked projects has almost not been studied at all (e.g. DeSanctis & Monge, 1999). Moreover, very little is known about successful management practices, and especially co-ordination practices (Katzy et al, 2000) of networked projects. Furthermore, there is evidence that insufficient or bad communication in a networked project may lead to poor project performance (e.g. Bruce at al. 1995; Wynstra et al, 2001). Therefore, further information about networked communication is needed.

To illuminate the area of networked communication, our literature review presented results from closely related communication research in NPD. Projects were grouped into four types according to the geographic and organisational dispersion of the project team members. Communication studies in traditional projects (single organisation, single location) were divided further into two streams studying communication either between individuals or between departments. Intra-organisational communication has also been studied in distributed projects (single organisation, across locations). Networked projects (between organisations) were divided into collocated and distributed projects. Communication in distributed networked projects has received some attention in studies about early supplier involvement and virtual organisations.

Studies have been made of communication practices and communication media used in different types of NPD projects and in different phases of projects. Also, communication barriers have been recognised. Most studies indicate that frequent communication both with internal project members and external parties should be encouraged. Further, the quality of communication (Moenaert & Caeldries, 1996), type of communication (Ancona & Caldwell, 1992b), and reason for communication (Pinto & Pinto, 1990) matter.

Communication in networked projects may face many barriers, e.g. geographical, educational and organisational. Geographical distance hugely reduces the probability of communication (Allen, 1984), especially interactive and ad hoc communication become more difficult. Differing backgrounds between persons from different departments reduce trust and make understanding between the parties more difficult (Griffin & Hauser, 1996). Also, resistance to sharing information between companies came up in studies concerning early supplier involvement (Ragatz et al, 1997).

Face-to-face communication seems to be a very popular and suitable media for many

purposes, since it can transmit very complex information. Face-to-face meetings are needed especially in the early phases of distributed projects to create personal networks and to build trust. Later on they are used for problem solving and co-ordination. After the "socialisation phase", in the beginning of the project, electronic communication can substitute at least for part of the face-to-face meetings (Boutellier et al. 1998). Electronic communication is certainly very important for networked projects, but it will probably just complement other forms, not replace them totally, thus adding to the total amount of communication. Probably more communication is needed in the early phases of a project than later on, since in the beginning communication is needed to create mutual understanding and to reduce uncertainty (Wynstra & ten Pierick, 2000).

Formalised communication structures, such as project review meetings and milestones, were suggested for cross-functional projects. Formalisation was expected to force parties to communicate, and at the same time it would increase also informal communication (Moenaert & Souder, 1990). Formalisation was seen to be especially suitable for co-ordination purposes in distributed projects. Besides formal communication, also informal communication is needed, for example, Pinto & Pinto (1990) found that cross-functional high co-operation teams had more informal discussions than low co-operation teams. Jarvenpaa and Leidner (1998) found that predictable communication was needed in virtual organisations. Besides that, also ad hoc communication should be supported, at least in early supplier involvement, according to Croom (2000). Informal and ad hoc communication are probably most suited for the early phases of a project, and later on more formalised structure will be needed (Moenaert & Souder, 1990).

Co-ordination in a networked project is very important, but at the same time also challenging, because networks increase complexity. Earlier research has suggested (according to Wiesenfeld et al. 1999) that external controls in virtual organisations should be replaced with internal controls. Kraut et al. (1999) proposed that co-ordination should take place through interpersonal relationships. This would be especially suitable, according to Kraut et al. (1999), when dealing with complex process comprising non-routine transactions.

To develop better products faster, the trend has been from a serial mode of operating towards parallel development, i.e., more parties are involved in product development at the same time. For example, cross-functional integration, concurrent engineering and early supplier involvement, all involve several parties in parallel. This situation has changed the requirements for communication, the previous "batch communication", from one group to another at the end of a phase, is no longer enough; a more interactive, two-way communication is needed.

3. Research design

This chapter concentrates on methodological issues. First, the research problems are stated. Second, the case study approach of this research and especially the process simulation method are described. Third, the chosen case networks are presented. Finally, the data collection methods, the data collected and data analysis are described.

3.1 Research problems

The main research problem is:

What kinds of communication patterns exist in inter-organisational product development projects?

This is clearly the main problem and consequently most of this research explores the communication patterns used in case projects. Since the main interest is in inter-organisational communication, very little attention is paid to communication inside the case companies, unless it very closely relates to inter-organisational communication, e.g. disseminating information received from a partner inside one's own company.

This research problem can be divided into following sub-questions:

- Who communicates with whom between networked companies?
- What kind of information is exchanged?
- Why does the communication occur?
- When does the communication occur?
- What kinds of communication media are used for each communication purpose?

The second research problem is:

What kinds of communication problems do inter-organisational product development projects have?

This study investigates communication problems, which are mainly due to a networked way of working. The hypothesis, based on the literature, is that networked communication is more problematic than communication inside a single company. Even though a thorough comparison between problems in networked and non-networked communication is not possible, the following sub-question is discussed:

- What kinds of communication barriers do inter-organisational product development have as compared to intra-organisational development?

The third research problem is:

How could communication in an inter-organisational project be enhanced and

supported?

This problem has managerial implications. Management faces constant pressure to shorten product development lead times. The literature about intra-organisational product development has found a correlation between effective and efficient inter-departmental communication and new product development lead-time, e.g. (Kessler et al. 1996). The hypothesis is that effective and efficient communication shortens product development time also in networked projects. Therefore, this last problem, how to enhance and support communication in networked projects, is presented. The actions proposed in this study are mainly based on the suggestions presented by the members of the two case projects. However, these suggested actions could not be empirically tested within this project.

3.2 Research approach

3.2.1 Case study approach

Case studies are used for many purposes, e.g. to provide description, test theory or generate theory. Case studies can be exploratory, descriptive, explanatory or confirmatory, they can consist of one (single case) or several cases (multiple-case) and they can be based on qualitative or quantitative data collection. Usually, they combine several data collection methods. Actually, a major strength of the case study method is the opportunity to use many sources of evidence (data triangulation) and many data collection methods (methodological triangulation). Multiple sources of evidence and multiple methods provide a better validity for findings. (Eisenhardt, 1989; Jick, 1979; Robson, 1997; Yin, 1994)

Action research can be a special kind of case study, most often a single case study, but also a multiple-case study is possible. In action research the researcher and a client organisation collaborate to solve a problem set by the client and at the same time contribute to research. The goal of action research is to generate findings that can be applied in organisations. Action research is often called participatory, since the researcher almost becomes part of the setting he or she is studying and quite often also several members of the organisation studied are included both in the research design and research process. The phases of action research include setting a problem, investigating the problem, giving recommendations, implementing them and finally evaluating the results and making a contribution to the body of knowledge. (Bryman, 1989)

The purpose of this study was to explore inter-organisational communication in networked product development projects, an area not yet well understood. The case study method was chosen because it offers a possibility to get a deeper understanding of the phenomenon. Addressing very specific questions, needed e.g. for a survey, would have been difficult, since this phenomenon is quite new and the theoretical background in this specific area is weak. Instead, by asking quite general questions this study aims to describe and understand networked communication, its patterns, reasons and problems. The case study method also gave a possibility to combine several data collection methods and thus provide better validity for the results. Methods used in this study for data collection were process simulation, interviews and questionnaires. They will be described in more detail in Chapter 3.4. The reason for choosing process simulation as the main data

collection method is explained in Chapter 3.2.2.

This case study consists of two new product development projects, or cases, therefore it can be called a multiple-case study. Actually, both projects have been done by companies from one network, the customer company being the same in both cases and the suppliers changing. Thus, in a wider perspective one could say that it is only a single case study of one network. However, the perspective chosen for this study is that of project level. For a network-level study more projects should have been studied to obtain an understanding of the whole network. Therefore, the term multiple-case study describes better the method used in this study.

Besides being a case study, this research is also quite close to action research, since both researcher and project team members participated quite actively in designing the study and setting its goals. Moreover, one purpose of the study was to find problems and suggest improvements that could be implemented in the organisations. However, the goals of the researcher and the goals of the participating companies differed somewhat. The research goal was to study communication patterns, whereas the goals of the companies were to shorten product development project lead-time, by enhancing collaboration and locating and solving problems. This study differed from action research, because the last phases of action research, implementing the suggested improvements and evaluating the resulting situation, were left out.

3.2.2 Studying organisations as complex systems

According to systems thinking, organisations can be seen as complex systems (Berends & Romme, 1999). Systems are composed of many elements or actors who are linked to each other by different kind of relationship links, feedback loops and communication links. Such systems can be studied by dividing them into pieces and studying the pieces, however, this approach loses information about the interaction between the elements. Berends and Romme (1999) suggest that simulation could be a useful tool when studying industrial or corporate systems as a whole. Since the objective of this research was especially to study the interaction between companies and projects team members, process simulation seemed to be a suitable method. Furthermore, because simulation aims to describe the whole system and its interaction we believed that it could help us to better understand the complexity of networked NPD projects and communication patterns in numerous inter-linked cause and effect situations.

The basic types of simulation are physical and mathematical simulation. One form of the physical simulation, used in social sciences, is role-playing. As our research method we chose social process simulation (Forssen-Nyberg & Luhtala, 1996; Pankakoski, 1998; Ruohomäki, 1994), which can been seen as one kind of a “role-play”. In this simulation, players are project team members “playing” their own roles while simulating a real NPD project. In other words, a process simulation session is a structured discussion, during which participants simulate their own real work activities on the bases of a simplified model of the work process (Ruohomäki, 1994).

Besides process simulation allowing us to get a big picture of interaction relationships in a NPD project, we had also other reasons for wanting to use it. First, the process simulation works as a process intervention with direct utility for the involved parties (Forssen-Nyberg & Luhtala, 1996). Second, it is an economic way of collecting large

amounts of rich data that can be partly validated during data collection since all stakeholders are present at the simulation session. Third, we wanted to experiment with using the process simulation as a method for data collection – earlier studies have mainly focused on the use of the process simulation for process intervention purposes.

3.2.3 Process simulation method

There exists a wide range of different kinds of simulations for many purposes. Here we will concentrate only on those simulations that have served as a model for our simulation. The process simulation method used in this study is very similar to simulation games described e.g. in the article by Forssén-Nyberg and Hakamäki (1998). Even though the earlier studies have used the term simulation game, we chose to use process simulation instead, because it describes better the method we used. This choice will be explained further in Chapter 4.9.4.

Earlier research has mainly studied the use of simulation games for process development purposes and simulated real work processes in organisations. These kinds of simulation games have been used e.g. for education and training (Ruohomäki, 1995a), analyzing the present situation and its development needs (Forssén-Nyberg & Hakamäki, 1998), facilitating the implementation of a new information system (Ruohomäki, 1995b), developing office work (Piispanen et al, 1996), developing (Forssén-Nyberg & Hakamäki, 1998) and redesigning production processes (Smeds & Haho, 1995) and testing new ways of working before implementation (Ruohomäki, 1995b; Forssén-Nyberg & Hakamäki, 1998).

Simulation games have proved to be very beneficial for participating companies. Many benefits are listed in all studies. First, simulation of a broader work process gives participants an overview of the whole process and increases the common understanding of the process (Piispanen et al, 1996; Forssén-Nyberg & Hakamäki, 1998; Ruohomäki, 1995a). It also helps to understand the cause-effects (Forssén-Nyberg & Luhtala, 1996), when all the actions and their consequences can be seen at the same time (Piispanen et al, 1996). Second, in simulation game problems, areas which need improvement and ideas for improvement come out (Forssén-Nyberg & Hakamäki, 1998; Smeds & Haho, 1995; Piispanen et al, 1996; Ruohomäki, 1995a). Third, simulation increases the participants motivation to implement changes and decreases their resistance to changes (Forssén-Nyberg & Luhtala, 1996; Ruohomäki, 1995a; Piispanen et al, 1996). Also, it facilitates co-operation and communication between participants (Forssén-Nyberg & Luhtala, 1996; Piispanen et al, 1996).

3.3 Case projects

This research consists of two new product development projects carried out by a company network in the Finnish consumer electronics industry. In both projects the customer company is ElectroCo, a global consumer electronics company. In the first case project we studied co-operation in a network, which consisted of ElectroCo, its 1st tier supplier, PlastCo, and its two 2nd tier suppliers, i.e., PlastCo's suppliers AutoCo and PaintCo. In our second case project ElectroCo co-operated with its 1st tier supplier PartCo. From now on these case projects will be called the *PlastCo case* and the *PartCo case* according to

the main suppliers of these projects. The structure of the network is shown in Figure 2.

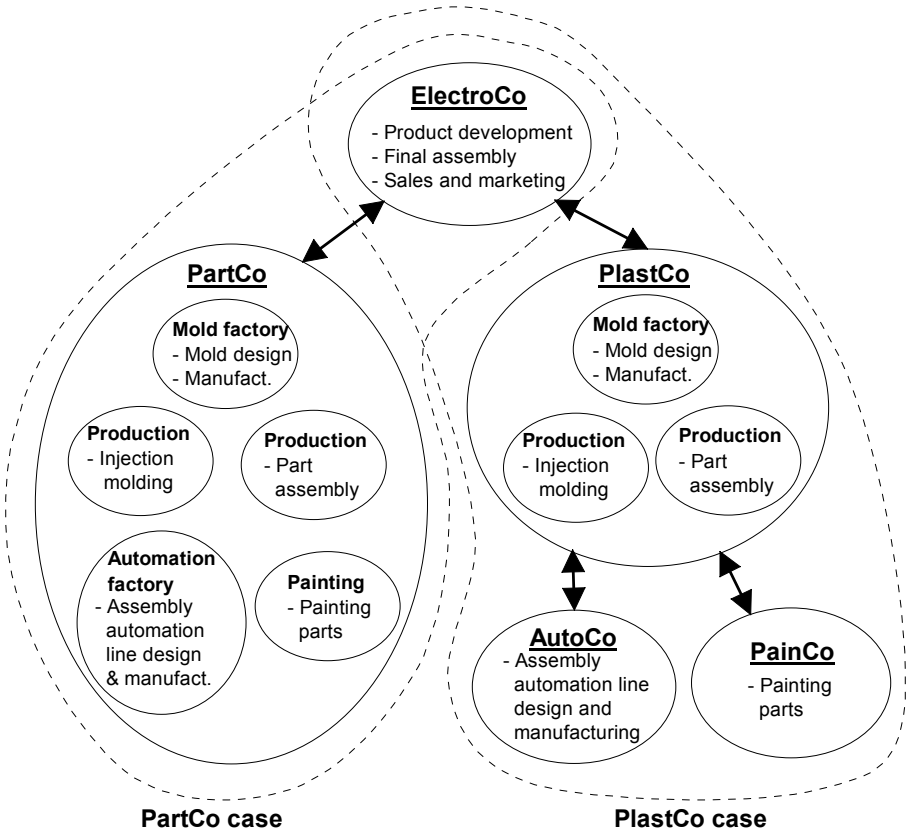


Figure 2. Companies and their tasks in the case network. Arrows in the picture illustrate both supplier relationships and main communication links.

In both case projects, ElectroCo was responsible for product development, final assembly, and sales and marketing. ElectroCo's suppliers PartCo and PlastCo are plastics firms, which both built manufacturing tools for the plastic parts, as well as manufactured and assembled the plastics components. PartCo did even more that this, it designed and manufactured its own automation lines for part assembly and it also painted the ready-made plastic parts. PlastCo bought these services from its suppliers AutoCo and PaintCo. AutoCo was responsible for designing and delivering the assembly automation lines, and PaintCo painted plastic parts before assembly.

PartCo and PlastCo are competitors, who both have done several projects with ElectroCo. They have worked with ElectroCo since the early 80s. It is not uncommon for ElectroCo to have several simultaneous projects with each of these suppliers. In each single project, only one of the two companies is involved. PlastCo has started its internationalisation, but is still quite small on a global scale, with most of its activities in Finland. PartCo is a somewhat larger firm with more global activities. Both 2nd tier suppliers, AutoCo and PaintCo, are small local companies, who have worked with PlastCo for about two years.

In both case projects all the sites were located in Finland, with the largest inter-site

distance of about 500 km. PlastCo's internal activities; sales, mould factory and production, were all in the same location. PartCo's activities, on the contrary, were more distributed: sales, mould factory, production and automation factory had 10 km as the largest inter-site distance, while painting was situated almost 500 km apart from the other sites.

The consumer electronics industry is characterised by a constant need to shorten project cycle-times, and a rapidly changing environment. Work is increasingly done in parallel with early subcontractor involvement. In the network studied, every new project involved suppliers earlier than before; in recent projects the suppliers were involved already in the concept design phase. Because of the changing requirements, none of the projects ElectroCo does with its suppliers is similar. Within this limitation we chose two projects, similar in the sense that the part designed was meant for the same use. Both of these projects where part of a bigger development project that included several plastic parts, software and electronics. For our simulations we chose only one plastic part from each project, the most important one.

The biggest difference in PlastCo project, compared to what is "normal", was that this was the first project in this network in which suppliers were involved before making the first injection moulded prototype. This increased the suppliers' possibility to influence the design of the final product. The distinguishing feature of PartCo project was the tighter than normal schedule set by ElectroCo.

3.4 Research methods and empirical data

3.4.1 Structure of the research

Process simulation was the main research method, all other methods, especially interviews, provided additional data. Besides data collection, also other kinds of preparations for process simulation sessions were needed. Table 5. presents the timeline of the research.

Table 5. The timeline of the research

Activities	Timeline, PlastCo case	Timeline, PartCo case
Planning the simulation with the companies	11 / 99	10 / 00
Process description	12 / 99	1 / 01
Interviews	12 / 99 – 1 / 00	1 / 01
Informing session at the companies	1 / 00	1 / 01
Simulation session	1 / 00	1 / 01
Feedback session at the companies	3 / 00	4 / 01

Both simulations involved the same kind of preparation. First, the idea of simulation had to be sold to the companies. Then, the planning of the simulation could be started. In the PlastCo case a common planning meeting was arranged with ElectroCo and PlastCo. The purpose of this meeting was to set goals for the simulation, to find a suitable project, and to choose participants for process description, interviews and simulation. In the PartCo case it was too difficult to find a suitable date for both parties, thus planning was done through phone calls and by exchanging emails.

After planning, a process description of the chosen project was done together with company representatives. Interviews were used to validate the process model, collect documentation and to ask interviewees about current communication patterns and problems. One week before each simulation session one-hour long information sessions were held in the participating companies. After these preparations simulation sessions could take place. These sessions were documented both by videotaping them and writing down very detailed notes. During the simulation participants were encouraged to write down on Post-it notes problems and development ideas. At the end of the simulation day participants filled in questionnaires.

The results of the simulations were reported to companies both in the form of written reports and as feedback sessions that all participants of the simulations could take part in.

Table 6. gives the number of participants at the planning meeting, at the process description meetings, at the interviews and at the simulation sessions. It also reports the number of questionnaires and Post-it notes received in the simulation sessions. The sections 3.4.3 – 4.4.7 describe the methods used and data collected in more detail.

Table 6. Information about data collection (tm = team member, ob = observer).

	PlastCo Case					**PartCo case**		
	Electro-Co	**Plast-Co**	**Auto-Co**	**Paint-Co**	**In total**	**Electro-Co**	**Part-Co**	**In total**
The number of persons at the planning meeting	4	3	0	0	7	No common planning meeting.		
The number of persons at the process description meeting	4	3	0	0	7	2	6	8
The number of persons interviewed	4	4	0	1	9	10	7	17
The number of participants at simulation session	8 tm 14 ob	10 tm 8 ob	1 tm 0	0 0	41	7 tm 5 ob	11 tm 2 ob	25
The number of questionnaires received	20	18	1	0	39	10	12	22
The number of Post-it notes received	Not coded according to companies.				89	11	15	26

3.4.2 Process stages chosen for simulation

The PlastCo-simulation session took place when the project was approximately halfway

through the product development phase[2]. The simulation covered the period from the first prototyping stage when PlastCo joined the project, to the specification freeze. The PartCo-simulation was held one year after the mass production release. In this simulation the later stages, i.e., detailed design and manufacturing integration and verification, were examined. By choosing successive development periods, it was possible to cover a larger part of the whole process. (Figure 3.)

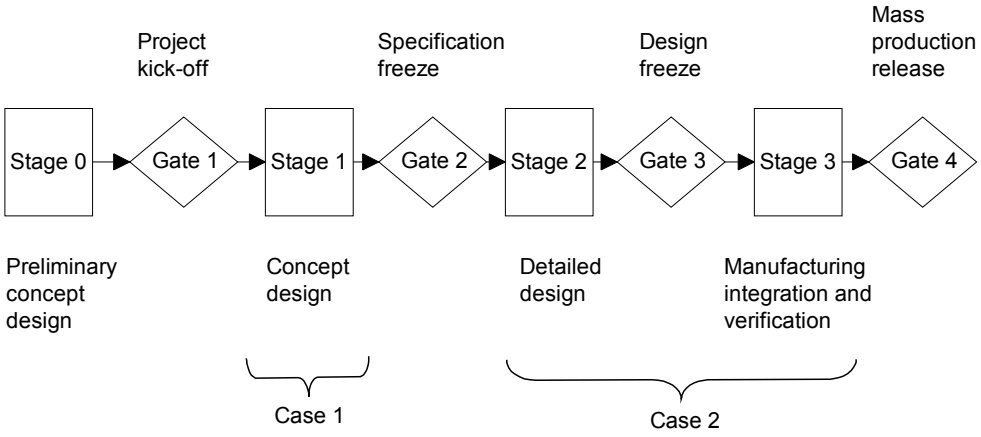


Figure 3. Main stages and gates of the product development process. The first simulation covered stage 1, i.e., the concept design phase, during which the product prototypes where designed and manufactured and the second simulation covered stages 2 and 3.

3.4.3 Process description

Before the simulation sessions, process descriptions of the case projects were made with the help of a few project team members from each company. The process description session for both projects lasted approximately four hours. A simple modelling process, sticking Post-it notes to the walls of a meeting room, was used. Both the process stages and the information flow between the different stakeholders were modelled. In both cases actually three concurrent processes were modelled: ElectroCo's process, its supplier's process and a joint process including e.g. common project meetings. Information was included in the model by adding documents and information needed above a task, and information or documents generated under a task. Also other information that was exchanged between companies, but not related to any tasks, was included.

The purpose of this modelling was not using any ready-made process descriptions, but to describe a real project with all its problems and iteration loops. The reason for this is self-evident: projects very seldom follow process models made in advance and this simulation wanted especially to present the reality that was otherwise very difficult to see in its entirety. After the initial process modelling sessions, the models were validated and refined in interviews.

[2] These product development projects lasted for approximately two years.

3.4.4 Interviews

The semi-structured interviews used were qualitative. They typically lasted from one to two hours. Interviews were used both to refine and validate the process descriptions, and to ask questions about current communication patterns and problems in the case projects. In addition to this, some interviewees also presented their process improvement ideas. These interviews provided very good background information for the simulation leader, or facilitator. This person should know quite a lot about the project in advance to be able to lead the discussion in the right direction. Discussion topics of interviews can be found from Appendix 1.

In the PlastCo case interviewees were selected in the planning meeting, and in the PartCo case project managers provided a list of suitable persons for interviews. These interviewees consisted of project team members, i.e., project managers, salespersons and engineers. In the PlastCo case nine persons and in the PartCo case seventeen persons were interviewed. The reason for the greater number of interviewees in the second case was that interviews provided very useful information for simulation sessions.

In both cases the interviewer took very detailed notes. In the PartCo case the interviews were tape-recorded, as well.

3.4.5 Project documents

The most important documents from the case projects were shown during the simulation session to complement the process description in which these documents were mentioned. The documents included e.g. offers, order, change information, measurement reports, acceptance reports, meeting memos and short email messages.

The plan was to collect these documents during the interviews. However, in the PlastCo case these documents were deemed to be so confidential that copies of them could not be given to researchers since the project had not ended yet and the product had not been introduced to the market. Instead, project managers brought the documents to the simulation session and showed them either using an over-head projector or their own computers and a projector. In the PartCo case documents were collected during the interviews as planned. In addition to that, project managers and a few other participants showed documents from their computers, when needed, during the simulation.

3.4.6 Simulation sessions

Both case projects had a one-day long (about eight hours including breaks) simulation session. The PlastCo-simulation session had 41 participants and the PartCo-simulation 25 participants. Approximately half of the participants were members of the case project team, e.g. project managers, designers, production persons, salespersons, quality engineers, and materials experts. The rest of the participants were observers. These included designers from other projects, process developers and managers. The simulation session setting is shown in Figure 4.

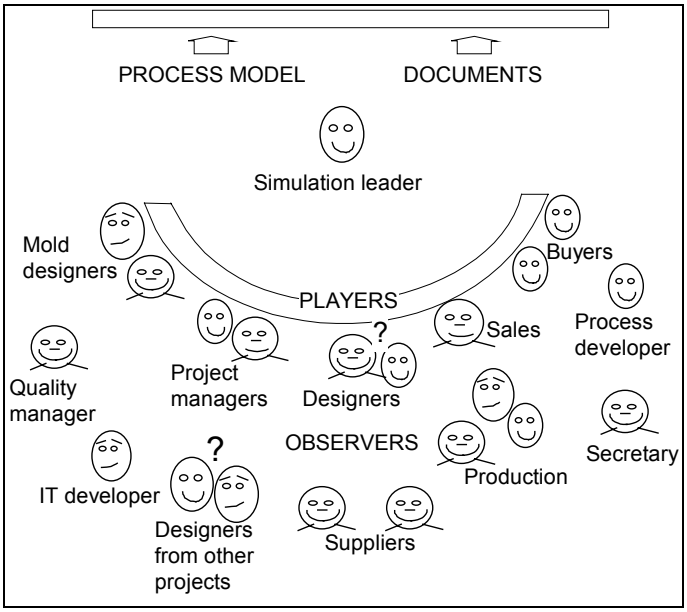


Figure 4. A model of a simulation session set-up and participants (modified from Forssén-Nyberg & Luhtala, 1996).

The agenda of the first simulation day consisted of four parts: presentations, simulation, group work and filling in a questionnaire. Under the leadership of one of the researchers the simulation followed the process description, which was projected on the wall. The most important documents were projected with an overhead projector. During the simulation, project team members described their work activities, communication flows and problems encountered. Many improvement ideas were suggested and discussed during the simulation. Observers were encouraged to comment, suggest new ideas and to contribute their experiences from other projects. To collect all improvement ideas and problems, participants were given Post-it notes, on which they could write down their thoughts. These notes were then collected on the walls. The whole session was videotaped and a scribe took notes of all the comments; these were synchronised with the videotape.

After the simulation participants selected and presented the most important development ideas as a group exercise. Finally, the participants filled in a questionnaire with both structured and open-ended questions about the simulation and process improvement needs. The PartCo simulation was conducted in the same way, with the exception that the group exercise was left out to have more time for the actual simulation.

3.4.7 Questionnaire

The questionnaire, at the end of the simulation sessions, was filled in by all the simulation participants that were present, a few participants had to leave earlier in both simulations. Somewhat different questionnaires were used in each of the simulations. In the PlastCo simulation the questionnaire concentrated mainly on participants' opinions about the simulation, they were also asked about process development ideas and needs, and problems in a networked project. The questionnaire in the PartCo simulation was very similar to the first one, but somewhat shorter. Also, some questions about the simulation where left out and more detailed questions about communication were asked. Both

questionnaires consisted of both structured and open-ended questions. The scale of structured questions ranged from one to five, one being “I completely disagree”, and five being “I completely agree”. Questions asked can be found from Appendix 2.

3.5 Data analysis

First, all the verbal information about each case study, interview notes, open-ended questions from the questionnaire, Post-it notes, and notes from the simulation sessions were computerised. Then, the data from each case was analysed by grouping all the verbal information into categories based on which preliminary conclusions were made and case study reports written. Quantitative information from the questionnaires was analysed using the SPSS program, and these results were also included in the case study reports. Findings from each case study were presented in feedback sessions to simulation participants and findings and suggested improvements were discussed together with the participants. Final conclusions and cross-case analyses were made after these discussions.

3.6 Summary

This chapter concentrated on methodological issues. First, three research problems were stated; this study aimed at exploring what kinds of communication patterns and communication problems exist in networked projects and how communication in networked projects could be enhanced and supported.

Second, the exploratory case study approach of this research was described. Third, the case networks were presented. Two case projects were chosen from the Finnish consumer electronics industry. The first case network had three levels: customer, supplier and two supplier’s suppliers. The second network had a customer, the same company as in the first case, and a supplier.

Finally, the data collection methods, the data collected and data analysis were described. The main research method was process simulation. During the simulation sessions participants, i.e., team members from the case projects, described their activities, communications, and problems during the project, while following a process description. Other supporting methods were interviews and questionnaires.

4. Results

This chapter presents the findings of this study: communication patterns and communication problems found from the case studies, improvement suggestions to networked communication, comparison of communication barriers in networked vs. intra-organisational projects, and a preliminary framework for communication in inter-company new product development, which was developed during the study. Finally, the use of process simulation as a research method is evaluated.

4.1 Communication patterns in case projects

Next, the communication patterns found from each of the case projects are presented. These results are mainly based on interviews with project teams' members.

4.1.1 The Change from a serial to a parallel mode of operation

As in our case projects suppliers were involved earlier than in previous projects, continuous communication was required. This caused a need for new communication patterns. In the early days of co-operation, the network had used the "over-the-wall" approach, (Wheelwright & Clark, 1992) giving information to the next development step only after the completion of the first. PlastCo and PartCo received designs from ElectroCo and then produced a mould and products according to them. In the projects under study, the interaction between companies resembled what Wheelwright and Clark (1992) call integrated problem solving. In this mode of communication, the downstream group is involved at the moment the upstream group starts working, thus getting a flying start for their own work. Figure 5 illustrates the direction of change in our case networks.

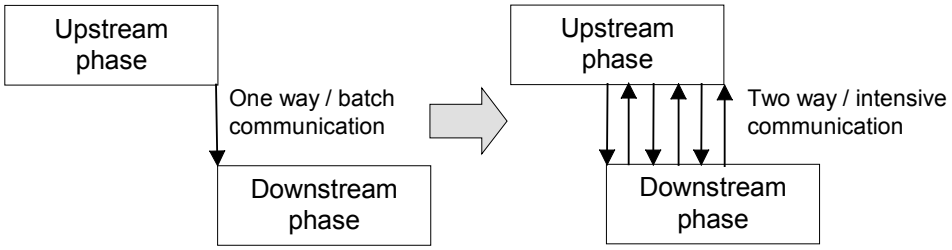
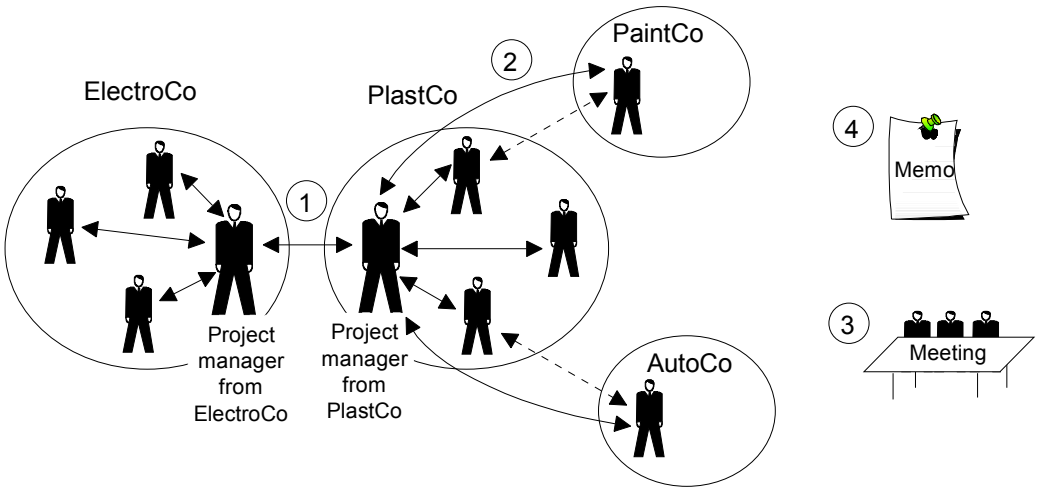


Figure 5. The direction of change in our case network is from a serial mode of working to parallel product development.

4.1.2 Communication patterns in PlastCo case

In PlastCo case we found three main principles that describe the current communication in the network: 1) project managers as gatekeepers, 2) weekly project meetings for change management and 3) meeting memos as the main source for project status and change information. Figure 6 illustrates these principles, which will be next described in more

detail.



1. Communication through project managers who distribute information further
2. PlastoCo's project manager communicates with supplier, excluding commercial documents
3. Meetings
4. Meeting memos

Figure 6. Communication practices in PlastCo case.

Project managers as gatekeepers

The information flow between companies, especially between ElectroCo and PlastCo, was mainly channelled through the project managers, who worked as gatekeepers (Allen, 1984; Tushman & Katz, 1980). The main part of the documentation and other information was first delivered to the own firm's project manager, who then sent it to the partner firm's project manager, who finally distributed the information inside his or her own firm. This pattern was especially strong between ElectroCo and PlastCo.

The communication between PlastCo and its suppliers mainly conformed to the same pattern, however, commercial communications such as orders and invoices were not sent through the project manager (the dashed arrows in the figure).

Besides documentation, also all other kind of communication mainly used this pattern. Direct communication between project members from different firms was not explicitly forbidden, but it was not encouraged either. It was considered important that project managers knew everything that was happening and that nothing, not even small things, were agreed directly, "behind their backs". In addition to this "rule", direct communication would have been difficult because the project members did not know all the relevant names and functions of other project staff across company borders. In the questionnaire, which was filled in at the end of the process simulation session, we got comments such as: "In the simulation I met for the first time several persons that I have been working with."

Weekly project meetings for change management

The fair geographical proximity of ElectroCo and PlastCo made it possible to have on-site weekly meetings between the two companies. In addition to the project managers, other

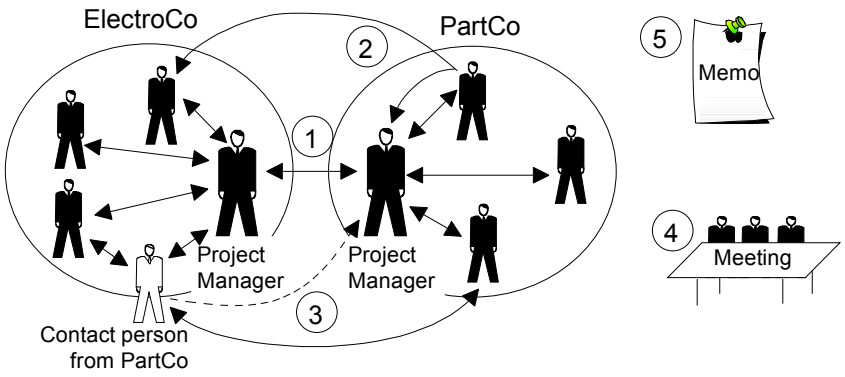
staff that was deemed necessary from both companies and occasionally also from PaintCo and AutoCo, were invited. Both organisations found regular meetings to be a very useful information sharing mechanism; earlier meetings had been scheduled more occasionally, on a need basis. For example, all changes to ElectroCo's product designs were discussed beforehand in these meetings and PlastCo could comment on the changes and suggest alternative solutions from the point of view of manufacturability. These meetings also prevented misunderstandings, since e.g. a product designer could explain what his changes actually meant, so that a mould designer would not interpret his drawing wrongly. In the simulation session several persons stated that by having these meetings and discussing all the changes together, they had both sped up the project and avoided a huge number of product change related mistakes**.** Meetings took place at the beginning of the project at ElectroCo's premises and later on, when PlastCo had already started to build a mould, meetings were held at PlastCo's premises. During these meetings also PlastCo's suppliers were visited.

Meeting memos as the main source of project status and change information

The main source of information on project status and changes were the memos that the project managers from either ElectroCo or PlastCo wrote during the weekly inter-company meetings. The writing and distributing of these memos was not systematic. The project managers sent the memos by e-mail to the meeting participants and to other internal project members that they thought might need the information; occasionally PlastCo's project manager sent the memos also to AutoCo and PaintCo. The memos contained information, e.g., about changes to the product, mould or timetable, and activities that should be undertaken. Several persons in the simulation session expressed a need to get these memos, in order to keep up-to-date with the happenings in the project. These project members were afraid that they might miss some information and waste their energies working with outdated information. Those kinds of situations were not new to these persons; they had happened frequently in the past. The memos were also the only source of information on schedule changes, even though they contained only the new deadlines, not comparisons to old schedules or any analysis of the effects of the changes to other tasks or partners.

4.1.3 Communication patterns in PartCo case

In the PartCo case, the communication principles resembled the principles found in the PlastCo case. This result is not surprising, because in both cases the customer, which has a quite powerful role, is the same. The five main communication principles found were: 1) project managers as gatekeepers, 2) direct communication between team members about details, 3) communication through a resident contact person, 4) project meetings for problem solving, and 5) meeting memos as the main source for project status and change information. Figure 7 illustrates these principles, which will be next described in more detail.



1. Communication through project managers who distribute information further
2. Direct communication between project members
3. Communication through contact person
4. Meetings
5. Meeting memos

Figure 7. Communication practices in PartCo case

Project managers as gatekeepers

Also in the PartCo case, the main information flow between the customer and the supplier was channelled through project managers. In this case, however, PartCo had its automation line factory and painting facilities as separate departments inside the own company, while PlastCo had bought them from outside. This helped communication somewhat, since it was easier for PartCo's project manager to understand what information these internal departments would need. In spite of this, especially the automation factory felt that they did not get information early enough and had wasted energy working with old information. Change decisions involving adjustments in terms of money or time were always channelled through project managers.

Direct communication between team members about details

In contrast to PlastCo case, also key project members, in addition to the project managers, had a few direct contacts between companies. For example ElectroCo's designers communicated with PlastCo's mould and automation line designers and quality personnel. These contacts involved mostly small detail decisions. Project managers in both companies were informed about all the decisions that were made during these contacts. Many team members thought that direct contacts are an easier way to communicate than through project managers, especially because it is faster. Nevertheless, direct contacts are not possible when team member do not know whom to contact. Moreover, the threshold to contact is higher, when one does not know the person one should contact well beforehand.

Communication through a resident contact person

In the beginning of the case project PartCo hired a contact person to be located in ElectroCo's premises. This contact person had a long experience in the field and a good knowledge of mould design. The objective was that this person would facilitate communication between the firms, and help ElectroCo's designers to design products that were easy to manufacture. The contact person stayed in close contact with PartCo's personnel. He visited PartCo at least once a month and was almost in daily contact with

PartCo's project manager, whom he informed about all decisions made.

Team members from both companies found the contact person to be of great help and that he sped up the whole project. First of all, he helped ElectroCo's designer to make better product designs from the PartCo's point of view, because he knew what kind of an effect design changes would have on a mould. This removed the need to send product files many times back and forth between companies for commenting, leading to a time saving of approximately two days with every change. Second, he knew the team members and their expertise fields inside both companies and could facilitate contacts. He was needed, for example, when a team member from either one of the companies had a problem and wanted to contact someone in the other company, but did not know whom to contact. Moreover, team members from PartCo felt that it was easier to turn to a familiar person, when they had a "small" problem. Earlier they would have waited until the problem was a "bigger" one before disturbing the customer. Third, the contact person spoke the same "language" as PartCo's mould designers, thus sometimes he could even be an interpreter between the parties.

Project meetings for problem solving

Project meetings between companies were held somewhat irregularly, normally when there were problems to solve. In practice, this meant approximately once a month, sometimes more frequently. The distance between PartCo and ElectroCo was somewhat longer than between PlastCo and ElectroCo, which might have been one of the reasons for fewer project meetings. This practice had both its strong and weak points. Meetings were never held in vain, but on the other hand, some team members complained about not having received information, e.g. about project progress, in time, whereas in a meeting they would have got that information. Several team members expressed a need for more systematic project meetings between companies, especially at the beginning of the project. These early meetings should have representatives from all functions of PartCo, also from manufacturing, because problems are easier to solve when they are discovered as early as possible. In the case project only a few persons were involved in the early phases of the project. Those functions that were not involved felt that they could have contributed to the project more, if they had been involved.

After the case project, PartCo has had internal weekly meetings both between functions and inside functions. PartCo's personal has found these meetings to be a very useful practice for distributing information. When team members know a bit more about a project than their own job, they can easier take over when someone is ill or on a business trip.

Meeting memos as the main source for project status and change information

The practice of writing and distributing meeting memos in the PartCo case was similar to the practice in the PlastCo case, i.e., project managers wrote memos during inter-company meetings and distributed them by email to persons they thought would need them. Most team members felt that they received the memos they needed and found them to be very useful. In the simulation some persons brought up the fact that there should be an easy way to outline memos. Everyone does not want to know all the details, so there should be an easy way to find just the information they need.

4.2 Cross-case analysis

In this chapter communication patterns of each case project, presented earlier, are compared. After that, the use of documentation and communication problems found from both case projects are presented and compared.

Both projects had quite similar communication patterns and problems. This is partly due to the fact that ElectroCo was an active partner in both projects. However, the partnership between ElectroCo and PartCo seemed to be, at least in these projects, deeper than the co-operation between ElectroCo and PlastCo. This could be seen e.g. from a more open atmosphere and communication in the PartCo case. In Table 7 communication patterns and communication related problems in the two cases studied are compared.

Table 7. cross-case comparison.

	PlastCo Case	**PartCo Case**
Basic network data		
- Network members and their activities	- ElectroCo: design, marketing and final assembly of consumer electronics products. - PlastCo: designing and building moulds, injection moulding and part assembly. - AutoCo: designing and manufacturing assembly automation lines for PlastCo. - PaintCo: Painting plastic parts for PlastCo.	- ElectroCo: design, marketing and final assembly of consumer electronics products. - PartCo: designing and building moulds, injection moulding, designing and manufacturing assembly automation lines, painting plastic parts.
- Size of the companies	- ElectroCo is a big global company. - PlastCo is a quite small globalising company with most of the activities in Finland. -AutoCo and PaintCo are small local companies.	- PartCo is a bit larger company than PlastCo and has more global activities.
- Travelling between companies	- A few hours by car between ElectroCo and PlastCo	- Requires an aeroplane trip
Network relationship between customer and its' 1st tier supplier		
- Length of the network relationship	- Approximately 20 years between ElectroCo and Plastco. (A few years between Plastco and its suppliers.)	- Approximately 20 years.
- Deepness of the relationship	- Not very deep yet. - Supplier selection was based on the fastness to produce the first prototypes.	- Close, can almost be called as a partnership. - Common process development activities.
- Customer's importance to supplier	- Very important customer, buys more that half of the production.	- One of the most important customers.
- Network hierarchy	- Quite hierarchical structure, supplier does what customer says.	- Hierarchical, but already a more equal situation than in the PlastCo case. Supplier dares to present its own demands.

- Trust	- Some lack of trust on both sides: the customer was afraid that product design knowledge would leak out and the supplier was afraid to lose its know-how to customer.	- More confidential atmosphere than in PlastCo case. Even though PartCo was not ready to discuss its internal mistakes with the customer.
Case project		
- Project chosen	- A totally new product design project. - One plastics part and its part assembly. - Simulated phase of the project: from supplier involvement to specification freeze.	- A totally new product design project. - One plastics part and its part assembly. (For similar use as in the PlastCo case.) - Simulated phase of the project: from specification freeze to mass production release.
- Project speciality	- Suppliers involved earlier than before, already before the first injection moulded prototypes were produced.	- Very tight schedule: project was to be done much faster than normally.
- Project team members	- Only a few team members between companies had worked together before, most of them had worked together internally.	- Less than half of the team members between companies had worked together before, most of them had worked together internally.
Communication between companies		
- Project managers	- The main communication channel. All documentation and main part of other communication between companies went through project managers. Project managers knew everything.	- Very important communication channel. - Bigger decisions and especially decisions that influenced budgets or schedules were always channelled through project managers. They were also informed about smaller detail decisions that were be made between project members.
- Resident contact person	- One of PlastCo's engineers was placed at ElectroCo's premises. This was a new arrangement, so there were no real experiences about this yet.	- PartCo's resident contact person, sitting at ElectroCo's premises, was hired at the beginning of the project. - Experiences in this project were extremely positive: he helped ElectroCo's designers to design products that were easy to manufacture and facilitated problem solving and contacts between companies. He informed PartCo's project manager about all the decisions.
- Direct contacts	- Were almost non-existent. Direct contacts were not totally forbidden, but not encouraged either. They would have been difficult to achieve, because team members from different companies did not know each other.	- Only a few persons, besides project manager, had direct contacts, e.g. ElectroCo's designer with PlastCo's quality persons, mould designers and assembly automation line designers. Project managers were informed about all decisions made.

- Meetings	- Were held almost weekly. All changes (e.g. design and schedule changes) were discussed before implementation. Were considered very useful.	- Were held when needed (when there were problems), approximately once a month. - After the project, internal meetings were started between and inside functions at PartCo. These meeting were considered to be a very good way of informing project members.
- Meeting memos	- Main channel to inform project members about project progress and changes. - Project managers from both companies wrote meeting memos during weekly meetings and sent these memos by email to each other and inside their own companies to team members that had participated in the meeting or that they thought might need the information. - Were considered very useful. Some team members complained about not getting all memos.	- Very important channel to inform project members. Were written and delivered the same way as in PlastCo case. - All team members who needed the memos had also received them. - A weakness of the memos was the amount of information they contained: the information needed was not easy to find (everyone did not need everything). Some structuring was needed.
Communication media used		
- Between companies	- Email was used as the main medium both for sending short messages and documents as attachments. - Offers and orders were sent first by fax, then by regular mail. - Phone calls were used often, especially when the matter was urgent. - Product documents were sent through direct electronic connection.	- The same as in the PlastCo case.
- Inside companies	- Mainly face-to-face and email.	- Face-to-face, email and paper documents.
Documentation		
- Company level	- Both ElectroCo and PlastCo had their own electronic archives for documentation, but they covered only small part of the documentation. - Team members had their personal archives, at ElectroCo mainly in electronic form and at PlastCo mainly in paper form.	- Both ElectroCo and PartCo had their own electronic archives for documentation, but they covered only a small part of the documentation. During the case project PartCo moved more information to common project files for internal use. - Team members had their personal archives mainly in electronic form on their personal computers.
- Network level	- No network-level document management or common archives.	- No network-level document management or common archives.

4.2.1 Communication patterns between companies

Next, communication patterns between companies in our case projects are compared. In both projects, the communication patterns seemed to be quite similar.

Communication in meetings

Both projects found meetings and meeting memos to be good communication practices. This suggests that rich media (meetings) are needed in networked projects. Also, informing the whole project team about the progress of the project and changes seemed to be necessary. In the PlastCo case meetings were almost weekly and the main reason for arranging them was to discuss all the changes together. Whereas, in the PartCo case meetings took place more seldom, approximately once a month and they were arranged when problems arose. The reason for this different frequency of meetings was probably the longer physical distance between companies in the PartCo case. Including travelling time, a weekly meeting would have taken almost a whole day for those who had to travel. However, discussing changes beforehand and not just after encountering problems would probably have been beneficial also in the PartCo case. As the same kind of practice was used earlier between companies in the PlastCo case but now after changing to weekly meetings, this new practice was considered to be better. In both cases, the meetings were held in similar locations; at the start of the project they took place on ElectroCo's premises and later on, when the supplier had something to show, meetings were arranged on the supplier's premises.

Communication through project managers

In both cases, project managers took care of most of the communication between companies. Almost all decisions were channelled through them, in the PartCo case some responsibility over small detail decisions was given also to lower level, project manager was just informed about these decisions. This practice of channelling everything through these key persons had both its benefits and drawbacks. Project managers knew everything that was happening in the project, and they really took care of the project co-ordination inside their own companies. Co-ordination responsibility was actually divided between project managers from both companies, both co-ordinated the work inside their own companies, and of course ElectroCo's project managers had to see that their suppliers' work was done properly . However, especially at PlastCo, some project members felt that if project manager was not available, e.g. on a business trip, working was difficult, since the project manager had all the contacts and even most of the documents, which were not easy to find while she was away. Besides co-ordinating the work inside their companies, project managers also delivered almost all the information about the project to their project team members. The main channel in both cases was meeting memos distributed by email. In the PlastCo case these memos were sent to all meeting participants and also to those team members project managers thought might need the information. Whereas, in the PartCo case, meeting memos were normally sent to all project team members. The practice in the PartCo case seemed to be better, since several team members in the PlastCo case complained that they had not received all the meeting memos, while in the PartCo case team members were very satisfied with the practice and thought that project managers were sending them all the necessary information. This good practice could be even seen in connection to our study, especially the project manager of PartCo sent all information about the simulation also to his project members, thus when we were arranging their interviews, we found they all already knew what it was about, and were very positive.

Communication through direct contacts

Direct contacts between companies were quite rare in the PlastCo case, while in the PartCo case they were more common. Actually, in both projects many team members would have welcomed this faster way of communicating as a common practice. However, in order to arrange direct communication some rules would have been needed, e.g. what kind of decision can be made through these contacts, who should communicate with whom and who should be informed. Besides the rules, direct contacts would have required that would-be contactors first knew the persons who should be contacted.

Communication through a resident contact person

Both case projects were the first projects between these companies that used a resident contact person, i.e., an engineer hired by the supplier, and based at the customer's premises. PlastCo had their own contact person based at ElectroCo' premises, but this was such a new experiment that they did not have any comments about it at the time this study was done. In the PartCo case, the contact person, an experienced engineer, was deemed to be a very good communication facilitator between the companies. He also helped ElectroCo's product designer a great deal, while giving him daily direct feedback about his designs from the manufacturing point of view. Probably this close consulting relationship substituted for some of the meetings with ElectroCo, which were not possible to have as often as in the PlastCo case. Weekly meetings in the PlastCo case provided the same kind of feedback to ElectroCo's product designer about manufacturability as the contact person provided in the PartCo case. Therefore, it seems that a resident contact person is very useful, especially when co-operating companies are geographically dispersed, and frequent face-to-face meetings are not possible. However, resident engineers need to have a very good knowledge of the field and know the supplier's people, practices and problems.

4.2.2 Project documentation

Most documents between the firms were sent in electronic form. Inside the firms, documents were either delivered further in electronic form or printed and delivered as paper copies. Documents were then archived inside the firms either in paper or electronic form. Inside PlastCo more paper than electronic documentation was used. In PartCo, some transformation from paper documentation to electronic documents could be seen during the case project.

None of the case companies had product data management systems (PDM) for daily project use. Even though ElectroCo had a PDM system, it was mainly used for archiving documents afterwards. Therefore, it was not very useful for the case projects. PlastCo and PartCo did not have a PDM system then, but they were planning to buy one.

All the three biggest companies, ElectroCo, PlastCo and PartCo had electronic archives for documents, but they did not cover all documentation. Also, documents were not updated frequently enough and it was difficult to locate documents. In practice, many project members had their own personal archives, typically as paper documents or in electronic form in their personal computers. For example, the project manager from PlastCo mentioned: "I have all project documentation, except product files, as paper printouts in my folders. Actually, that is the only place in PlastCo where the whole project

documentation can be found". At ElectroCo and PartCo many team members had their personal archives in electronic form on their portable computers.

4.2.3 Problems in communication

Based on information collected in process simulations (Post-it notes, discussions and questionnaires) and the interviews, several communication problems were identified. Most of the problems were similar in both cases, but also some case specific problems were found. The communication problems are listed in Table 8. They are described in more detail below.

Table 8. Communication problems in the case studies.

Communication problems common to both cases
- A lack of common communication and information exchange mechanisms and an over reliance on key individuals - A lack of understanding of partners' information needs and information generation - A lack of direct contacts - Non-working network-level document management
Communication problems specific to PlastCo case
- Lack of trust leading to the hiding of information - Misguided use of the information-push - Slowness of organisational adaptation to new communication needs in parallel development - Late arrival of orders
Communication problems specific to PartCo case
- Late involvement of some internal functions - Slow arrival of change information to some internal functions

Communication problems common to both cases

A lack of common communication and information exchange mechanisms and an over reliance on key individuals

In both networks the biggest problem in communication was a lack of common communication and information exchange mechanisms. In both projects, communication was heavily dependent on the project managers' ability to share information. Since the project managers were very busy, and the distribution of information was not agreed upon, information did not always move quickly enough and sometimes did not even reach the people who needed it. Many project members expressed a wish for making relevant information transparent to the whole network, e.g. through a project repository, instead of relying on single busy individuals to distribute information.

A lack of understanding of partners' information needs and information generation

Project team members in both projects were not familiar with the partner firm's processes or operating habits. The project members often did not know what kind of information the partner would need or what kind of information the partner could provide and when. In

practice this led to existing information not reaching the partner needing that information. For example, a project member from PaintCo complained: “I would like to automatically get all the information concerning painting that the project manager of PlastCo gets from ElectroCo. Now I have to ask for the information and it takes time. One reason for this is that PlastCo does not know what information we need.” People at PlastCo, on the other hand, complained about not getting all relevant information from ElectroCo. Moreover, they did not understand why ElectroCo required them to send e.g. a huge amount of measurement data to ElectroCo. The understanding of partners’ information generation and needs would increase if the network would be more transparent, e.g. the simulation sessions have already increased this transparency. This way people will get a better understanding of what information other team members need and where they can get the information needed.

A lack of direct contacts

Some team members in both cases felt the lack of direct contacts problematic. Direct contacts were difficult to establish both because they were not encouraged and because the team members did not know whom to contact at the partner company. In the PlastCo case there were almost no direct contacts except for contacts between project managers. In the PartCo case the situation was a bit better; also a few other team members, besides project managers, had direct contacts. However, sometimes in the PartCo case messages between two individuals were delivered through three or even four persons! Many team members considered direct contacts an easier way to communicate and hoped that in the future there would be more direct contacts.

Non-working network-level document management

At the network level, there was no working mechanism for document and version management in either one of the case projects. This led to situations in which it was very difficult to find documents and it was often unclear whether the document was the most up-to-date one. Also afterwards, when the project had ended, it was almost impossible to find old documentation.

As stated earlier, none of the companies had a PDM system for project use. All the three biggest companies, ElectroCo, PlastCo and PartCo had had their internal electronic archives for documents, but these archives did not cover all documentation. Also, documents were not updated frequently enough and it was difficult to locate documents. In practice, many project members had their own personal archives, either in electronic or paper form. Usually, it was only project managers who had all project documentation in their own archives, an exhaustive documentation could not be found from anywhere else. These kinds of situations were very problematic when, e.g. the project manager was not present and he or she was the only one who had the document. For others, it was very difficult, or impossible to find documents from the project manager’s personal files. Many project members would have welcomed a network-level document management system; even an internal system inside a single firm would have been an improvement.

Communication problems specific to the PlastCo case

A lack of trust leading to the hiding of information

Despite the long history of co-operation between ElectroCo and PlastCo we would not yet classify the relationship between these case companies as a partnership, since a lack of trust[3] still existed and has led to the hiding of information. Due to the nature of its business, ElectroCo wanted to prevent any information from leaking out, especially information concerning new products. For this reason the suppliers were given only the minimum amount of information needed as deemed by ElectroCo – in practice suppliers often received too little information. On the other hand, PlastCo wanted to protect its know-how from leaking to its customer. And to be trustworthy, PlastCo had to be very careful when giving the information they got from ElectroCo to its own suppliers. Therefore, PlastCo also rather gave too little information than too much.

This atmosphere of a lack of trust and the poor sharing of information was stronger than the legal agreements between the companies. For example, a project member from PaintCo claimed: "I do not get all the documents made by ElectroCo, even though we have agreed on this with PlastCo, because people in the field do not know about the written agreements and are too afraid to give us the documents".

In the PartCo case the atmosphere was somewhat more open and e.g. common development programs had been started. However, every issue was not open to discussion, e.g. PartCo did not want to talk about its internal mistakes in the process simulation session, while its customer was present.

Misguided use of the information-push

Besides complaining about not getting all the information needed, a few part-time project members from ElectroCo came out with an opposite complaint: they got too much information via project wide, intra-company mailing lists. These persons worked with several projects, so they were not interested in all details they received.

Slowness of organisational adaptation to new communication needs for parallel development

The case companies in the PlastCo case had moved fairly quickly from a serial mode of product development to parallel development with early supplier involvement. However, people's attitudes do not change that fast. Project members from the supplier's side were used to getting all the information they needed in one batch, after which they could proceed without any customer-initiated design changes. Now, they had to start with preliminary information, with the rest coming in pieces, and a constant risk of information change. A project member from PaintCo stated: "It would be much easier to get all information in one batch." It was difficult for these people to understand that the situation had changed drastically, now they were taken into project in the middle of the product development phase, not after it. A mould designer from PlastCo said: "I know that the situation has changed. Anyway, it is difficult to understand that when I have just finished

[3] Trust was not measured specifically. A lack of it was determined based on the interviews, when interviewees e.g. told about not daring to give information to other parties.

the mould design, ElectroCo wants to change the design and I have to abandon my earlier work and start it all from the beginning, even though I had done the best job I could!"

Despite these obvious problems, also positive comments were heard. For example, a mould specialist commented happily: "Designers from ElectroCo have accepted many of my ideas to change the design to facilitate manufacturing."

These comments show that good things for suppliers, such as the possibility to influence the design for easier manufacturing solution, are easy to accept, but the bad things such as changes and not getting all the information at once, are very difficult for them to understand. Many project members from PlastCo felt that ElectroCo was just so mean that it made these changes without caring what kind of trouble they caused in PlastCo. They were partly right; designers from ElectroCo seldom knew how much trouble a tiny change might mean to PlastCo.

The simulation session helped to close at least part of this gap of understanding between the partners. We got comments like this: "Now I understand much better ElectroCo and its endless design changes at the beginning of a project".

Late arrival of orders

For suppliers in the PlastCo case it was often very difficult, sometimes impossible, to write an accurate offer which had been requested by a customer, because the suppliers did not have all the information needed to make the offer. The customer did not have that information either, because there was no one who would have known at the beginning of the product development project exactly what sort of product would finally be produced, how much effort would be needed from the supplier, what materials would be needed or what kind of assembly automation line should be ordered. The supplier had to make a lot of estimates, which might have had fateful economic consequences, because a supplier often has to offer a too low instead of a too high price, in order to secure a deal.

Moreover, for the customer it was difficult to order in advance, because the customer knew exactly what to order only after the actual delivery of the product. According to the process simulation participants, an actual reversal of the order-delivery process had taken place several times in earlier projects between ElectroCo and PlastCo. For example, the order for a mould had arrived from the customer only after the mould had been used in production and the first parts have been delivered to the customer. Also in our case project, the prototype mould had been used before the order arrived. Late orders caused a lot of problems to suppliers, since they could not send invoices before getting an actual order. This led to a situation where the suppliers carried a large financial risk, since they never could be totally sure about actually getting an order for the work already done.

The problem of late orders was very familiar also for PartCo. However, in the simulated project, the problem did not occur in a very severe form. The order actually came quite early in the project, which surprised simulation participants when noticing the fact from the process description, they thanked the ElectroCo's buyer for his efficiency!

Communication problems specific to the PartCo case

Too late involvement of some internal functions

The most striking problem that was found especially in the PartCo case was too late

project entry of some of PartCo's internal functions, e.g. painting, manufacturing (both injection moulding and assembly), and automation line design. These functions expressed a need to be involved already in the early phases of the project, in order to be able to influence more on the easier manufacturability of the product.

Slow arrival of change information for some internal functions

Some of PartCo's intern functions also hoped to get more information about product changes as early as possible. Information about decided product changes did not always arrive right after they had been made to all internal functions. It had even happened that some functions had undertaken unnecessary work because they did not know that they were working with outdated information. For example, assembly automation line designers had worked once for two weeks with old information, not knowing that changes had been made which had a bearing on their work.

4.3 Suggested improvements

The most important improvement area for this network is lead-time, i.e., increasing the speed at which the network can bring new products to market. Effective and efficient inter-departmental communication has been found to correlate with new product development lead-time within a single company (Kessler & Chakrabarti, 1996). We hypothesise that this result also holds for company networks; by enhancing communication, we think that this network and other similar networks could make a huge improvement in lead-times. In this section we present five means to improve communication: 1) common communication patterns, 2) common operating procedures, 3) common principles for co-ordination and progress monitoring, 4) a common team-building meeting, and 5) a common information system. Both case studies support these suggestions and actually many of them were directly proposed by simulation participants. Common operating principles, a team-building meeting and a common data system were mentioned as possible solutions by several team members. Common communication and co-ordination principles were proposed on the basis of the problems presented by participants.

4.3.1 Common communication patterns

In the case network, project groups typically just jumped into new projects and started working without first planning how to work together and how to communicate. However, advance planning might have been useful. Especially, designing efficient communication patterns is important. These patterns include communication channels, i.e. who delivers, what information, when and to whom, who should communicate with whom, who can make decisions and how should the broader project team be informed. These communication procedures should be designed and agreed on at the beginning of the project.

4.3.2 Common operating procedures

Besides, common communication principles, companies in the case networks did not have common operating procedures either - not even inside a single company. It was mainly

project managers who decided how to operate in each project and in each situation. However, we believe that before starting a new project, project team members should agree on common operating procedures, including the communication patterns mentioned earlier. Designing these patterns and informing team members about them can be done e.g. in a joint team-building meeting at the beginning of the project. For networks with a long lifetime, the common operating procedures should probably be defined at the network level, not at the project level.

4.3.3 Common co-ordination and progress follow-up principles

Project members in a networked project are very eager to know how project is advancing in other parts of the network, because changes to one partner's designs or schedule almost always have an effect also on the work of the other partners. When they know how the others are advancing and what kind of changes can be expected, they can better arrange their own tasks.

An online project schedule for the whole network might be one solution. This schedule should be updated constantly otherwise people will not trust it. The impact of schedule changes to schedules in other parts of a network should also be included, but their implementation is very challenging.

4.3.4 Common team-building meetings

Understanding the processes – especially the needs for and the generation of information in a partner company – is a prerequisite for fruitful communication. Personally knowing the team members and their roles makes the initiation of contact easier.

A joint team-building workshop at the beginning of a networked project could both help understanding the partners' processes and help team members to become acquainted with each other. A process simulation could also be used during such a workshop. Our experience from three simulation sessions indicates that it is a good method for partners to meet, to learn about each other's processes and to further develop their co-operation. We think that the process simulation method could be used not only to simulate existing processes, but also as a way of practising new common ways of communicating and co-operating.

4.3.5 A common information system

Several persons in both simulation sessions wished for instantaneous access to the newest information – the objective should be transparency of all common information, not only schedules, to every network member. A joint project repository for all documents and other information was suggested. Using Internet technology, the whole project documentation could be available in one place regardless of its physical location. Information-pull mechanisms, instead of information push, could be used. Thus, everyone could search for and follow the information he or she is interested in and nothing else.

4.3.6 Different levels of improvements

The suggested improvements should not be done only at the level of single projects, instead, all levels of organisation should be involved to a suitable extent. Figure 8. presents three levels: company, project management and project levels.

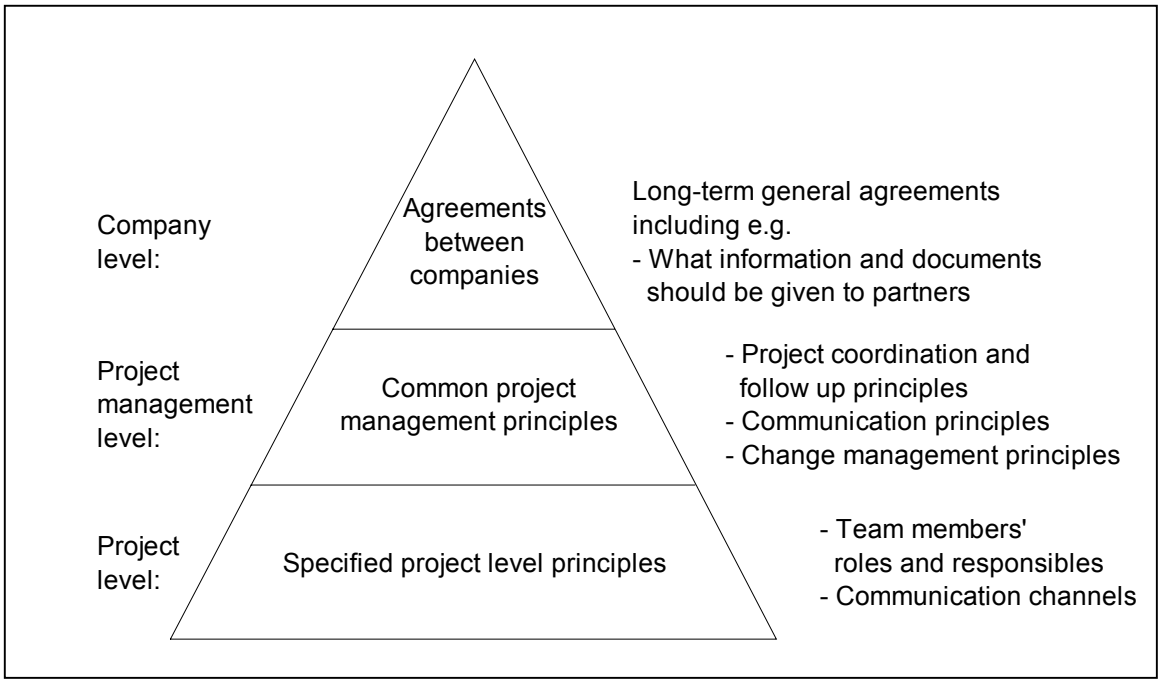


Figure 8. Levels of networked co-operation.

The basic principles for co-operation should be agreed on at the company level when signing long-term co-operation agreements between networked companies. These agreements should include the basic rules for co-operation, e.g. what information and which documents co-operating companies should give to each other. Also other decisions concerning the whole network, such as the decision to bring in a common data system for the whole network, should be made at this level.

The project management level deals with decisions about common project management principles that should be similar in all projects. There is no use to start defining those principles all over again when starting a new project. For example, in the case projects every project manager had his or her own principles, which lead to a situation where principles differed in all projects. Having common principles, besides reducing the work to define them several times, also facilitates the work of project team members, since they know how they should work and it is also easier for new team members to join the project in later phases. These principles include common communication, operating, co-ordination and progress follow-up principles.

In the lowest level, i.e. project level, common project management principles should be refined and applied to each project. For example, each team member's role and responsibility should be specified and communication channels defined, i.e., who communicates with whom and who should be informed about decisions. The project level refinements can be discussed and decided in team-building meetings at the beginning of

the project.

4.4 Elements disturbing inter-organisational communication compared to intra-organisational communication

Communication in inter-company product development projects seems to have both all the same problems as intra-company projects, but maybe in a more severe form, and they also have their own special problems. Especially intra-organisational projects, distributed across departments or sites, resemble networked projects.

This chapter describes seven elements that complicate the communication between networked companies, but do not normally so much interfere with intra-organisational communication: 1) geographical distance; 2) differences in organisational culture, "language" and terms; 3) a lack of trust and the hiding of information; 4) differing operating procedures; 5) difficulties in understanding a partner's processes and operating procedures; 6) differences in goals; and 7) differences in the information systems used. This list is based on our case studies, all these complicating elements were found from our case projects. These elements are next discussed with the help of communication literature about both intra-organisational and networked projects.

4.4.1 Geographical distance

Geographical distance, that e.g. Allen (1984) has broadly researched in intra-organisational projects, exists almost always in inter-organisational projects. Geographical distance makes arranging face-to-face meeting more difficult and also reduces informal communication. However, face-to-face meetings are very much needed in inter-organisational projects, since they give an opportunity for both parties to explain what they mean (Wynstra & ten Pierick, 2000). Interaction in face-to-face meetings helps participants to understand what the other partner requires from them and participants might even together improve the product design, like the companies in our case study. Also face-to-face contacts are needed for problem solving, since problems are often too complex to solve using other media.

Geographical distance is a barrier that is difficult to overcome. Some actions might at least lower the barrier: arranging a team-building meeting at the beginning of the project, hiring a resident contact person, arranging regular face-to-face meetings, applying a regular pattern of communication and creating communication rules. A joint team-building meeting would help project team members to get to know each other and their jobs and clarify common goals and design shared processes. Afterwards, communication using electronic media is easier, and face-to-face meetings can take place more seldom. A resident contact person seemed to be a good practice, at least in one of our case projects, to substitute part of the face-to-face meetings, since he could comment on product designs daily from the manufacturing point of view. Research about cross-functional communication (e.g. Moenaert & Souder, 1990) suggests that when communication between functions is difficult, arranging formal communication, e.g. in terms of regular meetings, also informal communication increases. Wynstra and ten Pierick (2000) propose regular verbal communication for early supplier involvement. A regular pattern of communication is needed to enhance communication, since when partners are out of

sight they are easily out of mind, too.

4.4.2 Differences in organisational culture, "language" and terms

All organisations create their own culture, which includes e.g. the behaviour that the members of an organisation appreciate and the special language and terms that they use. Differences in organisational language and terms used might arise from different educational backgrounds of persons, e.g. R&D personnel has different educational backgrounds than marketing personnel. These differences of course exist also between functional departments inside a company, but they are probably even wider between companies. While doing our case studies we noticed that inside ElectroCo a lot of abbreviations were used, most of which belonged to their own internal slang and they were not well understood by their suppliers.

4.4.3 A lack of trust and the hiding of information

The PlastCo case study revealed that there is still a lot of hiding of information and a lack of trust between co-operating companies. The literature of cross-functional integration has found incidents of a lack of trust between departments (e.g. Wheelwright & Clark, 1992; Matz et al, 2001). The reason for this lack of trust might have been differing backgrounds and thought worlds, a lack of communication between departments (Moenaert & Souder, 1990) and even rivalry between departments (Maltz et al, 2001). Since people from different departments have differing backgrounds, and do not have much contact, trust between them has not developed. Moenaert and Souder (1990) found that trust is a prerequisite for passing information forward and also using information from other departments, since a person who receives information might be suspicious about the objectives of the person who sent the information. Moreover, many studies find that frequent communication between partners is a prerequisite for trust (e.g. Moenaert & Souder, 1990). Thus, trust seems to be especially difficult to create, since a lack of trust prevents communication, and on the other hand, communication is needed to build trust.

Secrecy and a lack of trust between co-operating companies are probably even more severe and broad problems, than between departments, since company boarders bring with them also confidentiality issues concerning new product development. For example, in our case study, ElectroCo was afraid that suppliers might, by accident or even on purpose, leak product design data to outsiders. For this reason, ElectroCo preferred giving out too little than too much information. On the other hand, some people felt that PlastCo was afraid to lose part of its own know-how to ElectroCo. Thus, a culture of hiding existed on both sides. In the questionnaire there were several comments to the effect that co-operation between these four companies would need more trust and less secrecy to succeed.

An open atmosphere would surely enhance information flow and communication in a networked project, which would then also enhance the development of trust. Ragatz et al. (1997) found that trust, in early supplier involvement, is developed more through performance to expectations over a longer time period, than through formal trust development techniques. Ragatz et al. (1997) also proposed that top management should indicate that sharing of information is allowed and encourage it. This suggests that clear rules for co-operation and information sharing are needed. Employees need to know

which information they are allowed to share with their partners and which information is more confidential and should stay inside company borders.

Most studies presume that building trust requires personal relationships and face-to-face contacts. Jarvenpaa and Leidner (1998) found that it is also possible to build trust in virtual teams using only electronic media. They call this kind of trust swift trust. It is created through frequent communication using predictable patterns and including, besides task related issues, also social communication.

4.4.4 Differing operating procedures

Independent companies in a network quite often have their own processes and operating procedures, also for communication and information flow. The same may be true between departments, in a single company; the border between them can be almost as hard to cross as between companies. On the other hand, if a company wants to standardise its processes, or take a communication process into use across all projects, it is much easier to do than in a network. There are at least two reasons for this: first, a single company in a network cannot determine how the other members operate. Second, in a network, one company might have several customers from different industries and also several suppliers, thus unifying processes across all these companies and industries would be almost impossible. In practice, it is quite often the suppliers who have to adjust to the operating procedures of their customers, instead of the other way around. This leads to a situation where suppliers have to operate differently towards every customer. In the simulation session we got comments that the operating procedures differ also in all projects with the same customer, because every project manager is used to operate in his or her way and no one has even tried to unify these procedures. The simulation participants expressed a clear desire for these procedures to be unified.

4.4.5 Difficulties in understanding a partner's processes and operating procedures

A person working for a company normally sees only his or her part of the process and perhaps the phases which precede and follow his or hers. Seeing how the whole system works might help the employee to understand how his or her work affects the whole and other persons' work and how changing his or her actions might make others' work easier. In a network understanding the other companies' processes is even more difficult. This came out also in our case study. It was difficult for suppliers to understand the new way of working in parallel development. For example, in the PlastCo case some persons working in PlastCo even felt that ElectroCo was just being mean when it kept changing designs all the time, which increased the workload at PlastCo. If these persons had been familiar with ElectroCo's processes, they would have known that changes in that product development phase were expected, since the design had not been finalised. Moreover, if ElectroCo's designers had known how much trouble a small change could cause at PlastCo, they might have implemented their changes differently. Process simulation sessions helped the team members of our case projects to understand the partner company's processes and operating procedures at least somewhat better.

4.4.6 Differences in goals

The objectives inside a single company are normally the same, e.g., to profitably produce and sell goods and add shareholder value to the company. Departments may of course have their own more specified goals and departments may even compete with each other. However, in company networks the objectives for co-operation quite often differ, e.g., the customer may want to buy manufacturing as cheaply as possible and the supplier may want to build a long-term co-operation. These imperfectly aligned objectives might affect the openness of communication and also complicate understanding a partner. One means to clarify the goals of participating companies could be to discuss them openly at the beginning of the project. Aligning the goals might be difficult and not always even desirable. Even though the goals might still differ after they have been discussed, partners will probably afterwards understand each other's actions much better.

4.4.7 Differences in information systems used

Company borders also pose challenges for the usage of supporting information technology, like product data management (PDM) systems, in a network. The simulation participants expressed the desire to have all the information they needed in one place. A common product data management system for the whole network would be ideal, but implementing it would be extremely challenging. Many firms already have their own PDM systems. In general, the systems are not compatible with each other. A small, networked firm may end up in a situation in which all its customers have different systems; it is of course impossible for a small firm to use or acquire several different systems.

On the other hand, the customers will not let suppliers use their systems, because of their fear of the leaking of confidential information. The systems themselves would provide mechanisms for hiding information, but the problem is more related to feelings and attitudes. In our case network, people seemed not to trust information technologies – they wanted to have their own information physically located inside their company. Technically it would be possible to build a distributed solution, in which information is physically located inside every firm's own system, but still could be accessed through a common user interface, and which would meet the security demands of the companies in our case network.

4.5 Towards a framework for communication in inter-company new product development

Based on both the literature and the case studies, a preliminary framework (in Figure 9.) for communication in inter-company new product development was developed. Case studies were used both to test the framework and to add elements. The framework consists of seven elements: 1) communication needs, 2) communication requirements, 3) media choice, 4) communication process, 5) elements disturbing communication, 6) elements supporting communication and 7) established gains from networked NPD projects.

Elements 2, 3 and 7 are based mainly on the literature, elements 1 and 5 are based both on the literature and the case studies and element 6 is suggested mainly based on our case

studies.

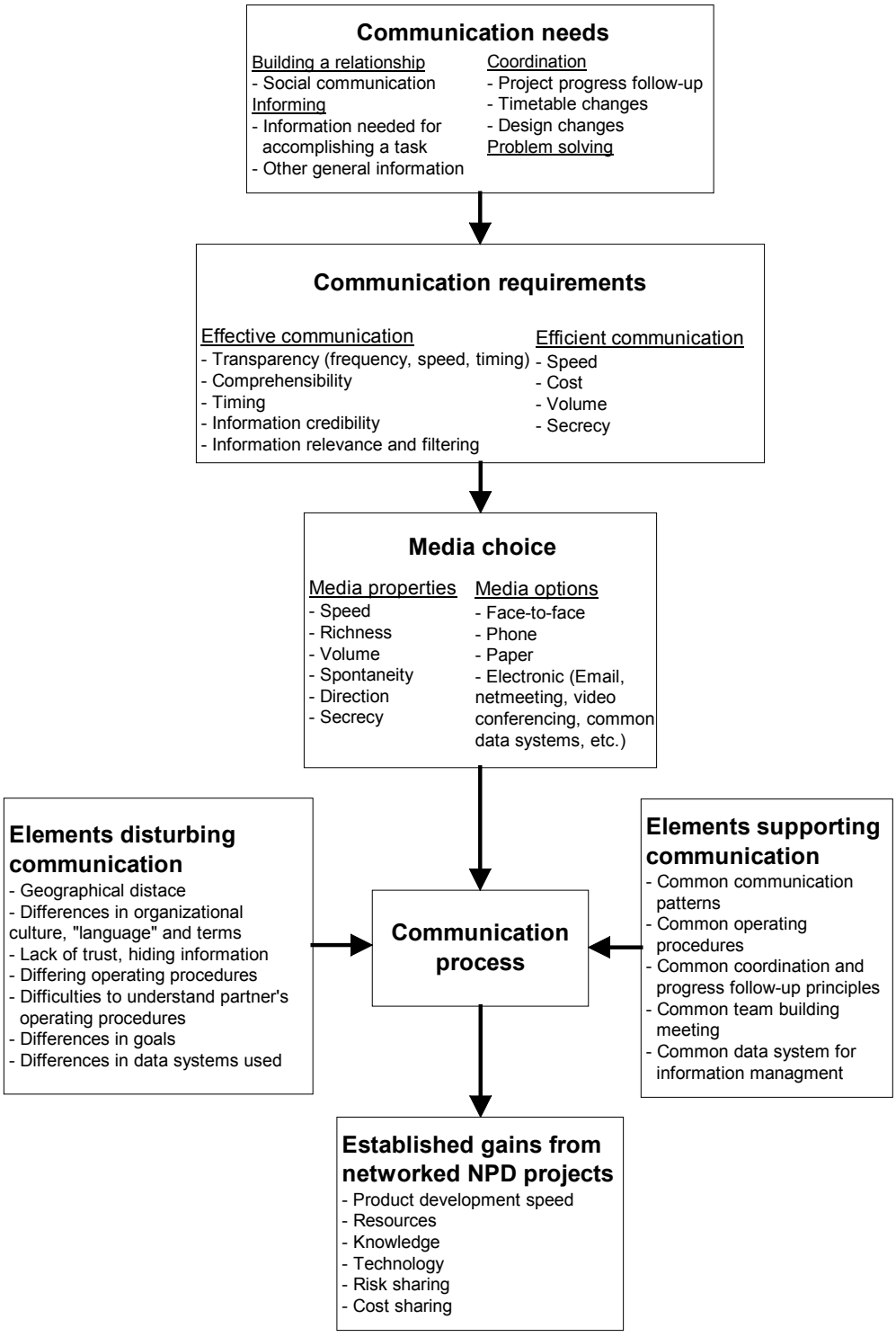


Figure 9. A preliminary framework for communication in inter-company new product development.

The framework aims to create a better understanding of networked communication in product development. It might be also useful when planning and improving inter-company communication. Initially, it is important to understand the different needs for

communication that arise. Based upon this understanding, the requirements for communication can be derived, and suitable media choices be made. By understanding the elements disturbing communication, action can be taken to eliminate or alleviate their effect. Similarly, elements supporting communication should be used to aid communication. Finally, when the communication in a network is arranged effectively and efficiently, the potential gains from networked NPD projects should emerge. In the following sections, the seven elements of this preliminary framework are described in more detail.

4.5.1 The need for communication

In a network there are several reasons for communication, e.g., to learn to know each other and to build trust, to co-ordinate activities, to transmit design data to the next step and to solve problems. Furthermore, the types of need for communication change depending, e.g., on the type of the network relationship, length of the relationship, type of the project and the phase of the project.

Allen (1984; 2000) made a well-known classification of technical communication, in a single firm case. He divided communication into three types: communication to co-ordinate work, communication to maintain staff knowledge and communication to promote creativity. Another classification used by Stahl et al. (1998) divided communication into four levels: informing, information exchange and feedback, co-ordination and decision-making, and problem solving.

This framework aims to include especially the needs to communicate that arise between networked companies. Therefore, from Allen's communication types particularly communication to co-ordinate work is essential. Communication to maintain staff knowledge is not so relevant for a networked project, since it can be seen mainly as a company internal activity. Communication to promote creativity could be very important also for a networked project, especially when the co-operation between companies is started already in the idea generation phase. However, that is not normally the case, at least not yet. Co-operation is usually still started at a later phase, after the most idea rich phase. That was the situation also in our case projects. Therefore, creativity promoting communication was left out also from our framework. We find that the classification by Stahl et al. (1998) suits our framework very well. We have combined their first two types, informing, and information exchange and feedback, into just one type and call it informing. Their third type, co-ordination and decision-making, we will just call co-ordination, and the fourth type, problem solving, we leave unchanged. Besides these three types we also add a fourth type: communication to build a relationship. This type includes all kinds of social communication that are important when building a relationship, but which are not included in other types. Thus, the communication needs of a networked project chosen to this framework are: building a relationship, informing, co-ordination and problem solving.

Building a relationship

Besides formal agreements made by top management, building a relationship between co-operating companies also requires creating personal contacts between project team members and an atmosphere of trust. Kraut et al. (1999) propose that personal

relationships are most valuable with non-routine tasks in virtual organisations. New product development is certainly not a routine task, therefore personal relationships are probably valuable in this field. Trust, between co-operating team members, is developed over time through daily project related communication and by fulfilling expectations (Ragatz et al, 1997). Normal task related communication quite often also includes social kind of communication. Actually, in a distributed network social communication without any task related reason is quite rare, since the geographical distance separating partners hinders ad hoc social contacts. However, the importance of social contacts should not be underestimated. The literature concerning distributed intra-organisational projects stresses the importance of a socialisation phase at the beginning of a project (e.g. Boutellier et al, 1998). This socialisation phase could include e.g. team-building meetings at the beginning of a project. The purpose of these meetings is, as explained earlier, besides discussing project tasks and goals, to offer team members an opportunity to meet and get to know each other and build personal contacts. When people get acquainted with their partners through social communication, also task related communication is easier. Social communication may be possible, besides through face-to-face contact, also by using electronic media. Jarvenpaa and Leidner (1998) found that social communication complemented task communication in virtual groups communicating though electronic media, and might have also strengthened trust.

Informing

Informing involves all the communication that a team member uses to get the information he or she needs to accomplish a task. Also the need to deliver general information is included in this need for communication.

Co-ordination

Co-ordination includes management activities like progress monitoring in different parts of the network, informing about design and timetable changes and figuring out the effect of the changes on the rest of the network. In a network, co-ordination cannot be left to only to managers. Our case studies brought out the need for team members to know in real time the situation in other parts of the network, which would allow them to better co-ordinate their own work. Also, earlier research suggests that virtual organisations should replace external controls with internal controls (Wiesenfeld, et al, 1999). For team members to be able to co-ordinate their own work they might need e.g. a real-time project plan or timetable, which is updated constantly.

Problem solving

Problem solving should be avoided by communicating enough before problems arise. In practice, however, problems cannot be avoided, and therefore a clear communication pattern for problem solving is needed.

4.5.2 Communication requirements

Communication in networked new product development projects has to be both effective and efficient. Moenaert et al. (2000) discussed several effectiveness requirements in internationally distributed intra-firm projects: transparency, codification and credibility;

and efficiency requirements: cost and secrecy. Maltz (2000) listed four dimensions that affect the perception of information quality between functions: credibility, relevance, comprehensibility and timeliness.

Effective communication means that the information transmitted must have an intended effect on the receiver (Moenaert et al, 2000). The lists presented by Maltz and Moenaert et al. consisted of items that could all affect communication effectiveness also in company networks. Therefore, we include all the items suggested in our framework, except codification, since it is already part of information comprehensibility. We also add information filtering to complement information relevance. We believe that in spite of network transparency, a sender does not always know what kind of information a receiver needs. Therefore, it might be sometimes better to send too much information and let the receiver to filter the information. For this purpose a receiver needs effective means to filter the information. Thus, the framework suggests that effective communication requires network transparency, information comprehensibility, correct timing, information credibility, and information relevance and filtering.

Efficient communication is low in resource usage according to Moenaert et al. (2000). The requirements suggested by Moenaert et al., cost and secrecy, are clearly relevant also in a networked situation. However, we believe that these requirements might not be enough. For communication to be efficient in a network, transmitting large volumes of information quickly is often needed. Therefore, our framework includes four efficiency requirements: speed, cost, volume and secrecy.

Transparency

Network transparency seems to be the most important effectiveness requirement, this was also true in our case study: the whole network needs the same information at the same time. Accomplishing transparency would remove the common problem of working with outdated information. Limited transparency also hinders people from recognising the relevant persons who produce or need information. Achieving full transparency is extremely hard in practice because of the following reasons. First, partners might not want to reveal everything to each other. Second, implementing transparency is a challenge. We do not know what kind of managerial practices, operating procedures and technical tools are needed to accomplish it.

Comprehensibility

Understanding the received information is largely dependent on the organisational and educational backgrounds of the communication partners. Persons from different disciplines use their own “code languages” and quite often have difficulties understanding each other. Longer-term co-operation usually lowers these differences. Sometimes an interpreter between the parties is needed, for example in the PartCo case, the contact person interpreted communication between ElectroCo and PartCo. Also, defining common procedures can alleviate this problem.

Timing

The timing of communication is critical; information received too late in a process can easily cause problems. On the other hand, giving preliminary information, that is likely to

change, to a partner who does not understand the preliminary nature of the information can as easily cause extra work and problems.

Information credibility

Perceived information credibility depends on the relationship between communicating partners. A long-term relationship with mutual trust is presumed to add credibility. Moenaert and Souder (1990) report that differences in inter-departmental organisational cultures inside a single company may cause a problem of credibility. Also, in this case, organisational and educational backgrounds matter. If the sender of information is not perceived as credible, the information he or she transmits might not be used. Moreover, cultural differences between companies are normally even larger than between departments, which might lead to more severe problems.

Information relevance and filtering

The information delivered has to be relevant to the receiver. Network transparency may easily cause information overload, therefore filtering is needed to separate relevant information from irrelevant.

Communication speed, cost, volume and secrecy

Efficient communication requires a possibility to deliver large volumes of information very fast. The cost of communication can be measured both in money and time (Moenaert et al. 2000). Co-ordinating activities across locations and companies takes a lot of time from key individuals, e.g. face-to-face meetings incur costs both by taking time from actually doing the work, and in travelling expenses. Besides these human resource costs also investment is needed in computer systems for electronic communication. Networked companies have to make sure that while transmitting information between companies it does not leak to external parties. These security issues may also add communication costs and exclude some communication channels for more confidential information.

4.5.3 Media choice

Different communication media have different properties. Maltz (2000) suggests three dimensions to describe inter-functional communication modes: richness, spontaneity and speed. McDonough et al. (1999) list three key communication needs of global new product development teams: speed, richness and volume. All these dimensions or needs, might actually describe properties of different communication media. We would like to complement this list by adding secrecy, mentioned in the earlier chapter, and direction. Direction is chosen, since communication can be one way, without any possibility for the receiver to interact, or two way, enabling interaction, or it can be directed from the sender to only one receiver or to several receivers. Thus, the framework includes six media properties: transmission speed, richness, volume, spontaneity, direction and secrecy. Besides media properties, the framework lists some media options.

Media properties

Different media have different properties and are thus suitable for different purposes. In a network it is a good idea to have a few media options available with different properties,

so that a suitable media can be found for each purpose. Of course there will be only a few main media that are used most often. It is not even practical to have all possible media choices available. McDonough and Kahn (1996) found that the best global teams in their study normally used two main communication media frequently and others more seldom. All teams should choose the media that is best suitable for their purposes, and that they are also willing and able to use. The six media properties listed in our framework can all be important for networked communication in different situations.

Transmission speed is nowadays a very important factor, the faster the information can be delivered, the faster the project can execute. In our case projects all critical documents were delivered between companies using fast electronic connections. Also McDonough & Souder (1999) suggest that electronic media, email and company databases, are the fastest ways to transmit information between distributed team members in a global setting. They list phone calls and faxes as second fastest. These suggestions were made with global teams in mind. Maybe in teams without time differences and using mobile phones a phone call could be the fastest communication media, whereas team members working inside the same networked company might find that face-to-face communication is the fastest media, as did the team members inside PlastCo.

In product development there is a lot of complex information, e.g. product designs and their changes. Besides these, inter-organisational co-operation could quite often be characterised by high equivocality, because team participants come from different environments and might have difficulties in understanding each other. For these kinds of situations Daft and Lengel (1986) suggest rich media, especially face-to-face communication and meetings. Face-to-face communication is quite often seen as the richest media choice (e.g. Daft & Lengel, 1986; McDonough et al, 1999), since it can convey several cues, e.g. through body language, and use several different media, such as pictures and verbal and written information. It also allows interaction between partners so that they can for example explain what they mean. Also in our case projects, team members had found rich media, i.e., meetings very useful. If face-to-face communication is not possible the next richest media choice according to McDonough et al. (1999) is videoconferencing. We suggest that networked communication will succeed better, if at least part of the communication uses rich media.

Transmitting large volumes of information is quite often needed, since e.g. product data, such as 3D- and 2D-pictures, contain a lot of information. McDonough et al. (1999) suggest that face-to-face meetings, normal mail and company databases are able to transmit large volumes of data. However, also other electronic media nowadays are capable of transmitting large volumes of data, e.g. direct electronic connection between companies.

Spontaneous communication can take place without much advance planning. For example, when project members are situated close to each other, they can easily meet face-to-face. Whereas for team members in a networked project, situated at distant locations, the most spontaneous media are probably phone calls or email messages.

The direction of communication can be either one or two way. Face-to-face communication, phone calls, teleconferencing and videoconferencing allow real-time interaction, while almost all other media, such as email and fax, can be used only one way at a time. Some media allow users to broadcast, making it possible to deliver the same

information simultaneously to several recipients.

Nowadays, many companies are worried about the security of the information they transmit either inside their companies or to outside partners. Especially electronic communication, like email usage, is often felt to be insecure. Accordingly, also this property of media has to be considered when choosing the right media for communication.

4.5.4 Elements disturbing communication

There are several elements that make effective and efficient communication difficult between members of a networked NPD team. Research by Allen (1984, 2000) shows that distance between project team members hugely reduces the probability of communication. Besides physical distance there is also quite often a distance between organisational cultures, organisational "languages" and terms used. These differences might make it more difficult for team members to understand each other. Additionally, networked companies quite often have their own processes and operating procedures, also for communication and information flow. Trying to standardise these procedures is very difficult. In particular, a network partner might participate in several projects in different networks with partners from different industries. Unifying processes across all these companies and industries is impossible in practice. However, the understanding of the different procedures used by different companies helps in understanding the needs for and generation of information in the various companies.

In company networks the objectives for co-operation quite often differ, e.g., a customer may want to buy manufacturing as cheaply as possible and a supplier may want to build a long-term relationship. These imperfectly aligned objectives might affect the openness of communication and also complicate understanding a partner.

Company borders pose challenges for the usage of supporting information technology in a network; firms often have their own systems, which may be incompatible with each other. Taking a distributed solution into use in a firm's internal network is challenging, in a network it is even harder. The simulation participants expressed a desire to have all the information they needed in one place. A common product data management system for the whole network would be ideal, but implementing it is extremely challenging. Even though technically this could be possible to implement, the problem is also one of feelings and attitudes; people are afraid of information leaks. They want to have their own information physically located inside their own company. This kind of lack of trust between companies often leads to the hiding of information; this was also seen in our study.

4.5.5 Elements supporting communication

We propose that communication in networked NPD projects can be supported by creating common communication patterns, operating procedures, and co-ordination and progress monitoring principles for the whole network. In addition, a common team-building meeting at the beginning of a new project could enhance future communication and co-operation. Finally, a common data system or a project repository for the whole network might be needed. The elements supporting communication are described in more detail in

4.5.6 Established gains

Finally, when communication in a networked NPD is effective and efficient, it should be much easier to attain the gains promised from company networking. These include, e.g., speeding up development; getting new resources, knowledge and technology to the project from outside partners; and sharing risks and costs of new product development with partners. Of course, only effective and efficient communication cannot save a project, which is developing the wrong product, but it surely can make a project developing the right product even more successful.

4.6 Process simulation as a research method

Process simulation proved to be successful as a research method. In this chapter the experiences and benefits of the process simulations are discussed. Also, some guidelines for successful simulations are suggested based on the experiences gained during this study. Finally, the term process simulation is discussed.

4.6.1 Evaluation of the benefits for the research

Process simulation was an effective and efficient method for collecting and partly validating rich data from several sources in one session. The biggest benefit, surprisingly, was that it quite easily opened the door to the companies. Product developers are often very busy individuals; it might be very difficult even to manage to arrange an interview with them, not to mention getting any information about their often very secret projects. When the companies realised that process simulation could offer them direct and fast gains, they became very interested and involved in the process. Of course this kind of research should always be useful also for companies, but benefits e.g. from interviews cannot be seen so directly. Process simulation, instead, offers direct gains e.g. by teaching participants the processes and bringing out process development ideas. All the participants can see the benefits in their own work. For example, since the PlastCo simulation took place in the middle of the project, the project managers presumed that the simulation would be of immediate benefit to the latter part of the project. In other words, process simulation provides an easier access to companies.

Simulation also offered rich data from several sources: interviews, collected documentation, process description sessions, and discussions, Post-it notes and questionnaires in simulation sessions. Obtaining data from several sources provided an opportunity to validate the findings.

Even though the process simulation session was the “main event”, most of the data had already been collected beforehand. Interviews especially provided a lot of useful data. Therefore, the preparatory work for the simulation is important not just as a prerequisite for a successful simulation, but also as a form of data collection. Even though the actual simulation session did not provide as much new data as the preparatory work, it put the pieces of data collected together, and emphasised the matters important to the whole network.

Besides discussions in the simulation session, also Post-it notes and questionnaire at the end provided useful information. In a simulation session some persons are inevitably quieter than the others are, or they just do not have an opportunity to put forward their views. To collect also these thoughts, a questionnaire and also Post-it notes are needed. Questionnaires also provide an opportunity to get answers from all the participants, they all answer, because the simulation is finished only after everyone has filled in the questionnaire. Post-it notes are meant for writing down thoughts, questions, ideas and problems during the simulation right away when they came to mind. Besides collecting data, these notes inspire discussion when simulation participants read each other's comments from the wall during the pauses. The facilitator's task is to activate the participants to start writing these notes. It is important that many notes are written already at the beginning of the simulation, which lowers the barrier to write them.

4.6.2 Evaluation of the benefits for the participating companies

As earlier research indicates (presented in Chapter 3.2.3), process simulation sessions are beneficial to participating companies in many ways. Simulation, e.g., gives participants an overview of the process and also works as a process intervention, often leading to an improvement in the ways of working.

Main benefits for participants

In this study, the participants of the simulation sessions thought that the three most important benefits gained from the simulations were: 1) getting a broad overview of the networked product development process; 2) bringing out problems and improvement ideas and discussing them together; and 3) meeting other project participants.

The first benefit, a broad overview, was mentioned as the main gain from the day in almost half of the answers to questionnaire in the PartCo simulation. It is clear that especially in a networked project most team members see only small part of the whole project and providing an overview like this can be an illuminating experience for them. Thus, from this point of view process simulations might be even more beneficiary for networked projects than they are for internal projects.

The objectives of process simulations can vary. The participating companies in this study were especially seeking process improvements leading to faster product development but also dealing problems that cause delays. The results from the simulations met their expectations, since a large number of problems and ideas were brought out.

Also, many team members felt that the simulation was a good opportunity to meet other project participants, especially from the other companies. Many of them, especially in the PlastCo case, had not met before, even though some of them had been working together for years.

Benefits for communication

From the communication point of view the simulations clearly provided the participants with knowledge and experiences which will facilitate communication later on, for example: 1) meeting project participants face-to-face; 2) getting a better understanding of information generation and information needs in the participating companies; 3) getting a

better understanding of the information requirements in the new parallel development situation; 4) getting a better understanding of current communication problems; and 5) arriving at a mutual understanding of the need for a common project repository.

Meeting other project participants face-to-face was important because many of them had not met before, even though some of them had been working together. Meeting a larger group of partners is useful in two ways. First, after meeting and learning each other's names and roles, it is easier to know whom to contact later on. Second, it also lowers the barrier to contact when you have met the person you are contacting.

Process simulation gives participants a better understanding of what kind of information participating companies produce and when and what kind of information they need and why they need it. Afterwards it is easier to ask for information. Participants will also understand better why it is important to produce and deliver information to their other partners. For example, in the simulated projects it was sometimes difficult for suppliers to understand why a customer wanted to have all kinds of information from them. Whereas, the customers did not always know what kind of information the suppliers would need from them. The simulation seemed to help the partners to understand better each other and their information needs.

Moreover, the new parallel development situation had changed the information requirements. First, all the required information was not available for the suppliers at the beginning of the project, the way they had been used to get it, because they were taken into project in the middle of the product development phase and that information just did not exist yet. Second, the preliminary information that suppliers were given could still change many times, which seemed to be very difficult for team members from the suppliers side to understand, at least in the Plastco case. Process simulation was an illuminating experience for many of them since they saw the customer's process and really understood that they are working in the middle of the product development phase. The simulation also overturned suppliers' former belief that the customer was just mean and wanted to disturb them by making changes all the time. The customer, on the other hand, understood how much rework one tiny change might mean for the supplier.

Participants also got a mutual understanding of the communication problems. Later on it will be easier to start solving these problems when both parties understand that they exist, and it is quite often the other party that could remove the problems experienced by the partner. Besides that, in both simulations it was apparent that there was a desire by the participants for a project repository to store the documents and information common for the whole network. After getting a mutual understanding of the need it is much easier to start implementing the change.

4.6.3 Some guidelines for successful process simulations

Based on the experiences from this study, six guidelines for successful simulations for research purposes are presented: 1) Benefits for both research and companies have to be remembered when planning the simulation. 2) A project, or part of the project, chosen for the simulation has to be suitable both in breath and depth to gain the objectives set. 3) The number of participants has to be chosen according to the objectives. 4) Careful preparation and data collection before the simulation session is essential. 5) The simulation facilitator has to understand the process and the main areas of interest already

before the simulation. 6) Key stakeholders have to be present in the simulation session. These guidelines will now be explained in more detail below.

First, when planning a process simulation for research purposes, both the research goals and the goals set for the simulation by the participating companies have to be taken into account. By creating a win-win situation it is easier to get companies interested. However, you should not forget your research goals either, when companies get involved they may start leading the simulation only towards their own goals.

Second, you have to choose a suitable sized area of a project or a process for simulation in accordance to the objectives set. If your objective is to give participants a broad overview of a networked product development process, you should choose a broader area, maybe a whole project. You have to also take care that in the simulation, discussions do not go too deep into details. If you want to do process development, instead, and find development ideas to specific problems or processes, then a more restricted area should be chosen. Also, discussions can concentrate more on details. Finding the right breath and depth is not very easy and specific advice cannot be given. In the PlastCo simulation the plan was to simulate a broader area than could be realised: also the latter part of the project from specification freeze to mass production release was chosen for simulation. However, a one-day simulation proved to be too short and the final part had to be left out. In the PartCo simulation, the chosen period of the project seemed to be just perfect, the simulation was finished in time and it covered the whole area chosen for the simulation. However, the simulated process had several very similar change cycles, instead of going through them all, only some of them could have been chosen for deeper examination.

Third, the number of participants should be limited and chosen according to the objectives. In a simulation, which aims to give an overview, a greater number of participants can be taken. For example in the PlastCo simulation we had 41 participants, which was suitable number for an overview simulation, but a bit too much for a problem solving and process development simulation. Because we wanted to have more of a problem solving approach in PartCo simulation, we limited the number of participants to 25 persons. That seemed to a quite suitable number of participants.

Fourth, data collection before the simulation has to be done carefully. It is essential to understand the main problems and other key areas of the process already before the simulation. Otherwise, the project facilitator cannot lead the discussion in right direction and ask the right questions. If the facilitator does not understand the process, participants might just “forget to mention” important but difficult issues. Besides that, networked product development processes are often so complicated that without any advance knowledge, it might be difficult to make full use of the simulation. Preparation time gives also a good opportunity to collect data for your research purposes.

Finally, you should make sure that key members of the project will be present. These key members are often so busy that if they do not see the importance of the simulation, they may just regard something else as being more important. However, the simulation cannot succeed if any of the key members are missing. One strength of a simulation is that everyone is present at the same time. It is so easy to blame those not present for all the problems. When everyone is present, real reasons for the problems have to be discussed and everyone can express his or her opinions.

4.6.4 The term “process simulation”

Earlier studies researching process simulation have used the term “simulation game” for very similar simulation sessions than those arranged in this study. Also, in the beginning of this study, we used the term process simulation game. However, while preparing for the PlastCo simulation session, that term turned out to be misleading. Some of the simulation participants were surprised when they heard what the simulation was really about. The first impression had been for some of them that the simulation was about playing a game, a fun competition with winners and losers. Compared to this expectation, the reality is much more boring; it is really hard work to sit in a simulation for an entire day and participate actively. Even though that can be fun too! When the participants get exited the time really flies.

To avoid misunderstandings, the term “simulation game” was abandoned after the first simulation and the term “process simulation” was used instead. Process simulation seemed to be closer to the reality. Also that term received some criticism: “It is not a real simulation when participants are just discussing about what has happened and not really simulating the course of events.”

Quite often a simulation is associated with computer simulations only. Social simulation methods are unfamiliar to many. In social simulation human beings are in leading role instead of computers, even though computers can be used as facilitators. Therefore, to prevent misunderstandings, the term “social process simulation” might be an even more illustrative name for the simulation method used.

4.7 Summary and conclusions

This chapter has presented communication patterns and communication problems found from case projects. Improvements were suggested to enhance communication to solve the problems found. Differences in communication between intra-organisational and networked projects were compared by describing elements that complicate communication between networked companies. Moreover, a preliminary framework for communication in inter-company new product development was developed. Finally, the process simulation method, used for data collection, was evaluated.

This study found that communication patterns between networked case companies were quire hierarchical, since most of the inter-company communication was channelled through project managers of co-operating companies. The weekly project meetings in the PlastCo case concentrated on change management. The meetings in the PartCo case were used for problem solving and they took place more seldom. Meeting memos, sent by email, were the most important channel to transmit project status information to project members in both cases. In the PartCo case also a few other direct contacts between companies, besides project managers, were used, and a resident contact person based at customer’s premises both reduced the number of change cycles and enhanced communication.

Communication problems recognised in both cases were: a lack of common communication and information exchange mechanisms, over reliance on key individuals, a lack of understanding of partners’ need for information and information generation, a lack of direct contacts and non-working network-level document management.

Five ways were suggested to enhance networked communication and to solve problems encountered: to create common communication patterns, common operating procedures and common principles for co-ordination and progress monitoring; to arrange a common team-building meeting for the whole project team at the beginning of the project; and to take into use a common information system.

Differences in communication between intra-organisational and networked projects were compared by describing seven elements that complicate communication between networked companies, but do not normally very much disturb intra-organisational communication. The elements were: geographical distance; differences in organisational culture, "language" and terms; a lack of trust and the hiding of information; differing operating procedures; difficulties in understanding a partner's processes and operating procedures; differences in goals; and differences in data systems used.

Based on both the literature and the case studies, a preliminary framework for communication in inter-company new product development was developed. Case studies were used both to test the framework and to add elements. The framework consisted of seven elements: communication needs, communication requirements, media choice, communication process, elements disturbing communication, elements supporting communication, and established gains from networked NPD projects.

Finally, the process simulation method, used for data collection, was evaluated. The process simulation seemed to be an effective and efficient method for collecting and partly validating rich data from several sources in one session. Even though the process simulation session was the "main event", most of the data had been already collected beforehand, mainly in interviews. However, maybe the biggest benefit of the simulation was that it quite easily opened the door to the companies to collect data, as the companies became very interested about the simulation. They also gained many benefits from the simulation: the participants received a broad overview of the networked product development process; the simulation brought out problems and improvement ideas that the participants could discuss together; and participant could meet other project members face-to-face. Moreover, the simulation itself enhanced communication between project members.

5. Discussion

This chapter first discusses the results, communication patterns found and improvements suggested, and compares them with literature. Second, limitations and evaluation of this study is presented. Finally, subjects for future research are proposed.

5.1 Comparison of the results with the literature

5.1.1 Communication patterns

Project managers as gatekeepers

The term gatekeeper is used in this study in a somewhat different context than in earlier studies (e.g. Allen, 1984; Tushman & Katz, 1980). These earlier studies have defined gatekeepers as individuals who are closely connected to internal and external colleagues and who translate and distribute external information to colleagues inside their projects and also facilitate their outside contacts. This was actually quite true also in our case studies, with an exception that in these projects the gatekeepers worked as messengers mainly inside a project, but between two co-operating companies. Earlier studies have concentrated only on internal projects and gatekeepers have kept contacts to all external environments. In our case studies gatekeepers were not so interested about all the external environments, but only their partner companies. In this study gatekeepers had also a bit negative side, since they were not so much facilitating contacts between co-operating companies, but might have even hindered contacts somewhat, while directing almost all the communication flow through themselves. In that sense they were really watching the "gate" between companies, and controlling the information transmitted between the companies.

Direct communication between team members

Wynstra and ten Pierick (2000) state that in early supplier involvement information exchange should be fast not to delay the project. Therefore, they suggest that communication lines should be short, e.g. development engineers from both sides should communicate directly with each other. Also several persons in our case studies suggested adding the use of direct contacts. However, our study also found difficulties in establishing direct communication, since relevant contact persons were not recognised. Also Moenaert et al. (2000) found similar problems in distributed intra-organisational projects. Their results indicate that limited transparency in a network leads to problems in identifying the relevant persons to transfer information to or to obtain information from. Moreover, our study suggests that there should be some kind of rules stating what kind of decisions can go through direct contacts and how others should be informed about these discussions and decisions.

Project meetings

In the PlastCo case, project meetings were arranged almost weekly and all design changes and problems were discussed together. These regular meetings in the PlastCo case were

found to be a very good practice. In the PartCo case, meetings took place more seldom and irregularly; they were held mainly when problems were encountered.

Regular meetings and milestone reviews (Bruce et al, 1995) were suggested also in the literature. A regular pattern of communication brings predictability to communication, which is important in virtual organisations according to Jarvenpaa and Leidner (1998).

Especially face-to-face meetings were suggested to be a good way to transmit complex information (McDonough, et al, 1999). Face-to-face communication was also suggested to be the best media for problem solving.

Communication through a resident contact person

Using resident engineers seems to be a quite common practice especially in Japan according to Hines (1994). Also other kinds of temporary personnel exchanges are used in Japan and also in other countries. Croom (2001) mentions that resident engineers are used for formal, more predetermined communication, in early supplier involvement.

5.1.2 Suggested improvements

Suggested improvements included common communication patterns, common operating procedures, common principles for co-ordination and progress monitoring, a common team-building meeting, and a common information system. Next, we will discuss these suggestions and compare them to the results found in the literature.

Common communication patterns and operating procedures

Creating common communication patterns and operating procedures between co-operating companies has not yet received much attention in the literature. The importance of establishing ground rules, or a framework for collaboration at the beginning of a project is recognised (Bruce et al, 1995). These rules include, according to Bruce et al., objectives and responsibilities agreed by all parties, and defined project milestones. Formal mechanisms, such as project review meetings (Moenaert et al, 2000) and milestones (Hameri & Nihtilä, 1997), have been suggested to direct communication in distributed inter-organisational projects. Moenaert and Souder (1990) claim that creating a formalised structure for communication that makes interaction mandatory is needed to enhance cross-functional communication. Also creating regular pattern of communication in virtual organisations was suggested by Jarvenpaa and Leidner (1999). These studies support our suggestion that some kind of predetermined patterns or procedures are needed to manage work in networked projects. However, what kind of communication patterns or operating procedures should be used is not so clear.

The literature provides some guidelines for networked communication. The following modes have been suggested as communication patterns in the early phases of the product development, frequent, interactive, verbal (Wynstra & ten Pierick, 2000) and face-to-face (Wiesenfeld et al, 1999) communication. Later on the communication can be either maintained by electronic communication (Wiesenfeld et al, 1999) or both electronic and face-to-face communication, when IT merely prolongs the times between face-to-face contacts (Boutellier et al, 1998).

Co-ordination and progress monitoring

Co-ordination between companies and across locations is difficult. There might not even be one project manager who could co-ordinate the whole project, but instead several project managers from every participating company who can co-ordinate only their internal activities. That was also the case in our case projects. Co-ordination has been discussed especially in the literature about virtual organisations. Wiesenfeld et al. (1999) suggest that virtual organisations should replace external controls with internal controls, such as motivation, trust and shared goals. To move towards internal controls, team members need to know when, what and how something is being done by other team members (Katzy et al, 2000) to be able to time their own activities correctly. This means that network transparency, suggested by Moenaert et al. (2000), would also be important from a co-ordination point of view.

Progress monitoring was suggested to be established by using a common project schedule that could be in electronic form in the project repository and would be updated constantly. Boutellier et al. (1998) have found quite a similar system in their IBM case study. They state that the core of the project information is a project plan, reflecting the current status of the project and the progress of the project so far. Also, it gives a preview of tasks and checkpoints, which have yet to be performed. This plan is maintained online and distributed via email to all functions involved in the project. These kinds of internal project plans are probably quite common for intra-firm projects, like in the IBM case. However, creating and maintaining a plan like this across companies is more difficult, as our case study showed. If this kind of a shared and constantly updated online schedule could be established it would also hugely improve the transparency of a network.

Common team-building meeting

The literature about distributed projects stresses the importance of a socialisation phase, including face-to-face meetings, at the beginning of a project. McDonough et al. (1999) even found that some firms make members of a distributed team meet face-to-face for one to two weeks. Also Pinto and Pinto (1990) suggest that project managers should devote enough time to building a cohesive project team. They had found that project teams quite often engage in project tasks too early, before team members have reached a sufficient atmosphere of trust to support co-operation. Early face-to-face meetings aim at the development of personal networks and the building-up of an atmosphere of trust (Boutellier, et al, 1998). At the same time shared goals can be agreed on (McDonough et al, 1999). After starting this team-building process by face-to-face meetings, electronic communication is easier, and times between face-to-face contacts can be prolonged (Boutellier et al, 1998). Thus, literature seems very much to support team-building meetings suggested in our study.

Common information system

Establishing a common information system, or a project repository, for all networked project information has been suggested. Katzy et al. (2000) discussed the concept of a knowledge repository in the context of virtual projects. They did not question the need for this kind of system; instead, they discussed the questions that have to be solved before implementing the system. The most important question according to them was where the ownership of the information should rest. Ownership affects e.g. where the knowledge

repository can be placed. This question came out in our case studies. Every company wanted to have its own information physically on its own premises. They were afraid that they would lose the information if it was in a shared system, physically out of their company borders. From the communication point of view, a project repository seems to be quite an unexplored area. The need for it clearly exists, but its qualities and use are not well understood. Several questions can be posed for future research: What kind of information and functionality should be included in a project repository? What kind of managerial practices are needed to support the use of a project repository? How does its use affect communication patterns?

5.2 Limitations and evaluation of the research

5.2.1 Generalizability

This research consisted of two case projects, which were studied quite thoroughly. When choosing the research method we also had to choose between the scope and the depth of this study, i.e., either studying several cases more superficially or only a few cases in greater detail. Since we wanted to understand more about networked communication, studying only a few cases at greater depth seemed to be the right choice. Consequently, this choice affects the generalizability of the results. However, broad generalizability is not even a useful goal for qualitative research (Schofield, 2000). Instead, generalizability can be increased by providing contextual information about the case study. This way the results can be applied to understand a similar situation deemed by contextual information (Schofield, 2000). Therefore, a substantial amount of information was provided about the networks studied.

This exploratory study has to be seen as a description of communication in two projects, shedding some light on communication practices in networked product development. The customer company in both projects was the same, thus it had quite a large influence on the communication practices in both cases. Clearly, more research is needed to be able to make broader generalisations about communication practices in networked product development.

5.2.2 Credibility

Using one form of triangulation, i.e., multiple data sources (Yin, 1994), contributed to validation and verification of the results. Semi-structured interviews, process description sessions, simulation sessions, post-it notes and questionnaires all provided data about communication patterns and communication problems, and also suggestions for improvement were made. The communication patterns described in this study were major patterns, which were confirmed from many sources, whereas, some communication problems were mentioned by only a few respondents. The communication patterns described facts that were familiar to everyone, while the communication problems were more related to special situations and concerned some persons more than the others. Also, some persons may feel that specific practices or situations are more problematic than some other persons might experience them, depending e.g. on the age or the background of the persons. For these reasons, we can only state that the problems presented were real

to those persons who described them, but we cannot say much about their importance to the whole network.

After collecting data from each of the case studies, company reports about findings and suggested improvements were written. These reports were delivered to all simulation participants either before the feedback session, or in the feedback session for those who had not earlier received them for some reason. The findings and suggestions were presented in the feedback session and they were discussed together. No mistakes relating to findings were found by the participants even though that was specifically asked for. The presented results mainly raised excitement and even further suggestions about how to carry them out. Moreover, a research paper was written about the PlastCo case study presenting both the findings and suggested improvements. Representatives from both ElectroCo and PlastCo read this paper and accepted it without finding anything to remark on.

5.2.3 Dependability

Suggested improvements were partly based on the suggestions collected from the simulations, interviews, Post-it notes and questionnaires, and partly suggested by researchers based on the problems found. Some other researcher might have ended up with different suggestions. Moreover, the suggested improvements were not tested in companies in practice. The only test was that these suggestions were included in the reports written after each of the case studies and discussed in the feedback session. Testing the suggestions would be a good subject for further research.

Besides ending up with some of their own suggestions about improvements, researchers might have affected on the suggestions presented by simulation participants. That could be the case especially with the project repository. Designing some kind of a project repository was in the minds of researchers already before the first simulation session. In that simulation the need of a project repository was suggested during many discussions by simulation participants. In that phase the researchers were not, at least consciously, leading the discussion in that direction. At the beginning of the second simulation session a sketch of a user interface and contents of a project repository were presented to the simulation participants to test its construction. This presentation probably influenced the results from the second simulation, so that the participants favoured project repository in their answers more than they would have otherwise.

The preliminary framework about networked communication was not tested either. Constructing the framework was based on limited literature about networked communication and the findings from this study. Also material from studies about different kinds of intra-organisational projects was used, selecting the findings that might also be suited to networked projects. Testing and revising the framework is left for future research.

5.3 Proposals for future research

5.3.1 Communication patterns

Communication in a networked project has not received much research attention yet. More studies to illuminate this area and to help manage networked projects are clearly needed. To find out what kind of communication patterns lead to successful projects, future research could e.g. compare communication patterns in successful and unsuccessful projects. We hypothesise that different communication patterns are suitable for different kinds of product development projects. We also hypothesise that communication differs in different phases of projects. For example, at the beginning of the project face-to-face communication might be needed, and later on email and videoconferences might be sufficient. Thus, future research could study what kind of communication patterns and which media are best suited to different phases of networked projects and to different kinds of networked projects.

5.3.2 Co-ordination and network transparency

Co-ordination in a networked project seems to be more complex than in an intra-organisational project. The literature suggests e.g. that instead of external controls network organisations should develop internal controls. We hypothesise that network transparency would help project team members from different companies to better co-ordinate their own work. This raises several questions for further research: How could co-ordination in a networked project be arranged? What should be centralised and what could team members co-ordinate on their own? How could the transparency of a network be established? What should be transparent in a network and what should not be transparent?

We hypothesise that the most important benefit of transparency is to be able to follow project progress easily, which would also make co-ordination easier. Future research should determine how this kind of transparency could be established. We suggest that e.g. software for progress follow up could be useful. Again, several questions are left unanswered. e.g.: What kind of software is needed? How should information be fed in and how could it be kept updated and on time?

5.3.3 Starting a networked project

The starting phase of a networked project seems to be an important period for the success of a project. Earlier research has mainly concentrated on the phases before really starting the project, namely the choice between make or buy, and partner selection. What happens when a project is started? What should be agreed on at the beginning of the project? How should a project be managed? These questions have not received much attention yet. However, we believe that the starting phase is crucial for the project. Future research could study what should be agreed on about communication and operation principles. Earlier, we suggested that a team-building meeting is needed at the beginning of a project. Future research could determine what these team-building meetings should include, and test what kind of team building meetings are useful.

5.3.4 Project repository

Earlier this research suggested that project repository would be needed to store and give easy access to information common to whole networked project. Future research could test whether this concept works and what properties this system should have. Several questions can be raised: What information should the project repository include? What functionality should it have? Who can have access to data? How can the system be realised technically, e.g. what kind of architecture should it have? How can the security of the system be guaranteed? How could easy data insertion and updating of information be arranged? How can new networked companies join the system easily? How could companies own systems be linked to the project repository?

5.3.5 Process simulation

Process simulation proved to be a good method for network use, since it gave the participants an opportunity to see the whole networked project, develop processes and learn to know other members of the project. The use of process simulation for different kind of purposes in networked projects could be designed and tested. For example, simulation might be used in the team-building meeting to simulate future phases of the project in advance, and plan how teams should act in different kind of situations and when problems occur. Simulation could also be used to plan, test and teach new communication patterns and operation principles for networked projects.

5.4 Summary

This chapter first discussed the results, communication patterns found and improvements suggested, and compared them with literature. The results were very much supported by the literature. Communication patterns such as direct communication lines, regular project meetings and the use of a resident contact person seemed to be good practices also according to the literature. The importance of several improvements suggested, such as common communication and operating principles, a team-building meeting in the beginning of a project, and the use of a common information system, was recognised also in the literature, but advice for practical implementation could not be found.

Second, limitations and the evaluation of this study were presented. This exploratory, single-case study can be seen as a description of communication in two projects, shedding some light on communication practices in networked product development. Contextual information about the case studies was provided, so that generalization to similar situations could be possible. The credibility of the results was improved by using multiple data sources. A limitation of this study was that suggested improvements and the communication framework could not be tested in companies in practice.

Finally, subjects for future research were proposed. Future research should study what kind of communication patterns could be best suited to different phases of networked projects and to different kinds of projects. Arranging co-ordination in a networked project, and accomplishing transparency to support co-ordination are challenges, which need further research. The starting phase of a networked project is essential to a project's future success. Research should clarify which actions are beneficial in the early phases and what should be agreed on between partners. A project repository could be a useful

tool for a networked project, but it still needs to be designed and tested. Also, process simulation might be beneficial for networked use, e.g. to plan, test and teach new communication patterns and operation principles. Different uses of process simulation could be tested.

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Appendix 1

Discussion topics in the semi-structured interviews.

1. Background of the interviewee
   - Position / tenure in the company / tasks
2. Checking and correcting process description
3. Communication practices
   - What was agreed about communication practices in the beginning of the project?
   - Do you communicate with the customer / supplier? With whom? When? Why? Using what media? What information is exchanged?
   - Who else communicates with the customer / supplier? With whom? When? Why? Using what media? What information is exchanged?
   - What kind of information do you normally communicate with your customer / supplier?
   - What kind of practices do you have for meetings / change management / schedule management? How is informing about these arranged?
   - What other formal communication practices does your company / project employ internally?
   - What kind of informal communication do you employ company internally / externally with partners?
   - For what kind of communication do you use email / phone calls?
   - What other media do you use? For which purposes?
4. Communication problems
   - What kind of communication problems does your project have internally / between partner companies?
   - What other practices are problematic?
5. Improvements needs
   - What practices in your project could be improved?
   - How could the communication / information flow be improved?

Appendix 2

Questionnaire in PlastCo case.

Most of the closed questions were not included in this study; therefore these questions are not listed here either.

Closed questions (1 – I totally disagree,…, 5 – I totally agree, 9 – I do not know):

1. The simulation helped me build an overall picture of the simulated process
2. The simulation added to my knowledge about co-operation needs / communication needs / time dependencies / interfaces / need for team work / documents / need for a common language / process milestones
3. The simulation helped to bring new operating principles to networked co-operation
4. I can make use of the lessons I learned from the simulation
5. The common process still needs development
6. The simulation was useful for ElectroCo / PlastCo / AutoCo / PaintCo

Open-ended questions:

1. What are the biggest deficiencies of project documents?
2. What are the most important improvement areas between these networked companies?
3. Which measures would best promote further development of networked co-operation?
4. What are the biggest hurdles for the development of networked co-operation?
5. What should be simulated next?
6. What did the process simulation gave you? Why was it useful?

Questionnaire in PartCo case.

Closed questions (1 – I totally disagree,…, 5 – I totally agree, 9 – I do not know):

1. The simulation gave me a good overall picture of the whole project
2. The simulation added my knowledge about the need for co-operation between companies
3. The simulation added my knowledge about communication needs
4. The simulation added my knowledge about documents used in the project
5. The simulation added my knowledge about partner company's processes
6. The simulation added my knowledge about my own company's processes
7. The simulation was very useful for me
8. The simulation was very useful for other participants
9. The simulation was very useful for developing ElectroCo's processes
10. The simulation was very useful for developing PartCo's processes
11. The simulation was very useful for developing a common process between companies
12. The simulation was very useful for developing communication and information flow between companies
13. The simulation brought out good development ideas
14. The simulation brought out the most important problems in ElectroCo's process
15. The simulation brought out the most important problems in PartCo's process
16. The simulation brought out the most important problems between companies

17. All persons needed were present in the simulation session. (Open-ended: If not, who was missing?)
18. The similar simulations should be arranged in the future
19. The process area chosen was suitable for simulation. (Open-ended: If not, which area would have been better?)
20. A project repository would be useful for networked projects
21. A project repository would speed up networked projects
22. A project repository should have / both common documents for the network and company internal documents / only common documents / common schedule / meeting memos / latest 3D and 2D pictures / product specifications / requests for proposals, offers and orders / reclamations / document template / acceptance reports / change information / tool progress reports / measurement data / FMEA / visual quality requirements / production volumes
23. In the simulated project, the communication and information flow were very well arranged
24. Information flow is an important improvement area
25. PartCo should be taken to projects earlier that currently
26. PartCo's suppliers should be taken to projects earlier than currently
27. The communication and information flow should be improved especially between ElectroCo and PartCo / inside companies / between ElectroCo and PartCo's suppliers / between PartCo and its suppliers

Open-ended questions:

1. What was the biggest benefit of the process simulation in your opinion?
2. How could the simulation have been improved?
3. What kinds of benefits might a common project repository bring to a networked project?
4. Was the simulated project a typical project between the companies? If it was not, how did it differ?
5. How could information flow be improved in networked projects?
6. What kind of information would you need more of? How would you like to get that information?
7. What are the biggest problems in projects, such as the one we simulated today? How could these problems be removed?
8. What are in your opinion the most important improvements, that could shorten lead-time from the first contact between partners to mass production release?
9. Other comments: