Designing the Communication interface between R&D Units and manufacturing

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Sammanfattning
Abstract

This master thesis presents a theoretical analysis of the interface between the Research & Development units and manufacturing. Streamlining this interface becomes more and more crucial for the smooth and high volume production. A literature research and a theoretical analysis of the crucial elements of inter-departmental communication between design and manufacturing build the basis for an improved communication model. The model acts as a guideline for the implementation of change processes. It emphasises the importance of both structural and individual elements of interventions. Both elements are important and necessary for the success, but their moment of result separates them. Hybrid methods counterbalance these differences. A first questionnaire issues the actual level of communication at the involved companies; a second questionnaire ascertains the attitude of the employees towards the proposed interventions. The model as a framework can be applied in general to all organisations, since the interventions that are necessary to be implemented are resulting from the analysis of the specific environments.

Nyckelord: Inter departmental communication, organisational development, organisational improvement, communication channels, R&D-manufacturing interface
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Preface

This Master thesis constitutes the closure of my diploma degree in Wirtschaftsingenieurwesen at the University of Kaiserslautern, Germany. After an exciting exchange semester at Linköping Institute of Technology, Sweden, I was interested in writing my master thesis in Linköping, which I was finally able to do between May 2007 and November 2007.

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1 Introduction

1.1 General situation

The communication between different departments in a company or, more general, in a value chain is becoming a crucial factor for success. The workflows in industrial companies, and also in non-industrial organizations, are incrementally complex and it is discerned that a 360° view is essential to come to a decision. Whereas in traditional sequences only a fraction of the organisation was affected by decisions in other departments, the increased complexity lead to the involvement of more views in the decision-making-process. This is highly relevant because the disregard of an opinion would inevitably lead to problems in that specific section. And even a small section could cause major disturbances in the production flow. To avoid those major faults, communication between the departments is necessary. Several approaches of development processes for new products pay attention to that. In these stage-gate-model processes, the decisions come out in cross-functional teams. In the cross-functional teams experts of the involved functions discuss the requests and seek for a consensus solution. The main purpose of cross-functional teams is to avoid disturbances before the product will be introduced into the market; they should develop stable production processes. With the market introduction that aim should be achieved and the project based teams liquidate them.

The necessity for the so called cross functional communication is recognized, widespread, and commonly used in new product development processes. But also in the regular production process, following the market introduction, there is a need for communication and coordination between departments. However, even if the advantages of inter-functional communication are known and esteemed, the research is lacking of deeper knowledge in non-project issues. Project-based team communication is the most spread instrument for improvements in cross-functional communication and coordination but, in the long-term, other communication ways seems more favourable.

In the actual case, members of the HELIX project group, further explanations in the following section, recognized problems in their inter-functional communication, especially in the communication between their research and development units on the one side and their manufacturing units on the other side. The problems didn’t occur in the development processes but during the regular operations when minor improvements require changes. At the
development processes the awareness for potential problems is given. However, for minor improvements during the regular work the awareness is much weaker. The combination of weak awareness and the still strong potential impact of the changes on the workflow lead to overtaken defects in the output of the Helix Partners.

1.2 Actual project

1.2.1 Present project programme

The project is located in the HELIX research programme idea development, entrepreneurship and innovation. Sustainable growth is one of the most important aspects for industrial economies and for a constant growth it seems to be necessary to achieve a high level of innovation. A prerequisite for that is an increased efficiency within existing organisations. The efficiency can be increased by changes in either idea development or entrepreneurship in terms of organisational settings. These processes offer a large range of research issues to take into consideration within the HELIX framework.

As mentioned above, the practical relevance of the problems is highly interesting for HELIX. And also several companies express their interest in issues related to idea development and entrepreneurship renewal. Within HELIX research will be organised to explore how to organise learning and change and idea processes.

1.2.2 Project group

The specific project group, called Communication Specifications and Experience between Product design and Production, was initiated by the HELIX partners BT Products Inc., SAAB Inc., Siemens Turbomachinery Inc., IUC Östergötland Inc. and the County Council of Östergötland by expressing their deep interest.

They realized problems by transferring information between production and product development. The transfer of that information is essential to synchronise planning and acting of the operations. In the existing manners the transfer is performed either physically by persons that move between the departments or from structures and processes. Regarding the personal transfer, planned as well as unplanned, spontaneous meetings are used.
Since the partners are dissatisfied with the existing manners, the purpose of the project group is to explore the difficulties within different types and methods of interaction in an analysis of the actual situations. Subsequent possible opportunities for further improvements should be identified. More general, the communication should be facilitated and improved.

As postulated by the HELIX research strategy the planning of the project is done interactively by researchers and the industrial partners. The partners present, in case studies, their data collection out of their daily working life, while the researchers’ contribution is literature reviews, questionnaires and document analysis. The linkage between both activity systems, research and practice respectively, are the interactive seminars. Here problem definition, presentation of the work, and issuing further steps take place.

This thesis, as part of the research, contributes a literature research, the development and analysis of a questionnaire as well as a first improved communication framework to the project group. Since the framework should be used by the HELIX partners, it is limited by the requirements of these; especially it is only focussed on the interface between R&D units and manufacturing.

1.2.3 Structure of the thesis

After this introduction into the underlying research and the actual project group that leads to a short presentation of the issue and motivation, chapter 2 and chapter 3 will provide the necessary theoretical backgrounds. Chapter 2 will present the theory and prerequisites for communication, whereas chapter 3 will be a literature research about inter-departmental communication. It will be shown, that while there is deep knowledge and extensive literature available on intra-departmental communication during the development process of new products, the field of regular production is quite underexplored. This theoretical background will be used as the basis for a questionnaire and the first communication model. In chapter 4, a questionnaire is developed to ask the actual ways of communication, especially inter-departmental communication between product design and production, company wide, and intra-departmental. The construction of the improved model for communication between product design and production will be explained in chapter 5. In the second part of the questionnaire, some parts of the model are to be evaluated. In chapter 6 the analysis of the questionnaire part regarded to the framework will be discussed. This should be a first evaluation and expose opportunities for further improvement. Chapter 7 provides an
evaluation of the model on base of the second questionnaire and a finalising summary. Figure 1 shows a flow chart of the thesis.

Figure 1: Structure of the Thesis
2 Theory on Communication within Organisations

In the first chapter some theoretical backgrounds should explain the versatility of the intra-organisational communication. First a comprehensive overview presents four perspectives on intra-organisational communication, they are all based on basic components but they all add some additional components. They perspectives are separated by their locus of communication.

In chapter 2.2 the impact of organisational settings on intra-organisational communication will be described. In chapter 2.3 an enumerative listing shows that communication consist of several dimension, with a continuous transition between the extreme strengths of the scale.

2.1 Perspectives on intra-organisational Communication

The field of intra-organisational communication is a wide area and embraces organisational as well as communicational attributes. With numerous and disparate variables is seems impossible to provide a universally valid model. Each direction of impact has its own justification and evident reasons. A comprehensive overview is given by Fisher (1978) and Krone et al. (1987); they proclaimed a four perspective approach, without advocating a general superiority of one of the approaches. They rather gave a variety of perspectives, since all of them potentially contribute to an overall understanding of the intra-organisational communication.

Each perspective contains different concepts and relationships as being crucial to the communication process. Since the perspectives could be grasped as views from different origins, they all provide other features that are significant. This leads to a more complete understanding of the communication and give further clues how the communication process can be improved and on which elements. As the distinction between the perspectives, the locus of communication is chosen. It determines which element of the communication process is receiving primary emphasis for a given perspective; the locus is the central location of where communication takes place.

The statement of the different views on communication is rather meant to be understood as distinct perspectives for examining relationships among elements of the communication process. The perspectives do not build on each other or represent an evolution in a linear
order. They have been developed independently from each other but they incorporate the same basic components. As a consequence for their distinctions, they provide further components.

### 2.1.1 Basic Components for Communication

Each of the four distinct perspectives, presented in Fisher (1978) and Krone et al. (1987), consist to some extent of basic components; namely message, channel, sender/receiver, transmission, encoding/decoding, meaning, feedback, and communication effects. Their exact definition varies in nuances from one perspective to the other but the main meanings for them are constant.

The first component, *message*, can be described as the semiotic of the conveyed verbal or nonverbal communication. The message is semiotic because there is no interpretation of the content. Since the message is meant to transmit from one end of the chain to the other, both *sender* and *receiver* are required. The sender is the source of the message, he sends it, while the receiver is the destination of it and he deciphers it. Between the ends of the chain is the *channel*, the channel is the medium used for the message to travel from sender to receiver. The range of channels is a continuum from light waves for nonverbal message to modes as radio or computers for verbal and visual messages, respectively. The channel can also be used as a buffer of the message. While the channel refers to the medium, in which the message travels, the actual sending and receiving is the *transmission*. The concurrent involvement of receiver and sender is important, because without it, the message would get lost. When the channel is used as a buffer, the buffer replaces the receiver and acts as the sender during forwarding the message. Written communication behaves in that manner. When the message is received at the destination the *decoding* of the previously *encoded* is due. Before transmitting, the sender creates the message, while receiver will decipher it after accepting.

With encoding and decoding the message, the individuals formulate *meaning* by interpreting or making sense of the message. Since the encoding process does not have to lead to the same meaning as it was when initialising the message, a *feedback* facilitates the congruence in the interpretation of initial and received meaning. All communication processes are conducted to achieve a result, the *communication effect*. The effect that will be shown in the different perspectives has a broad range of definitions. But it typically refers to the outcome of the message exchange process.
To those basic components of the communication process each perspective will add some new components. The new components will be consistent with the assumptions and the loci of communication of each perspective.

2.1.2 Four different Perspectives on Communication

Four perspectives on organisational communication were presented in Fisher (1978) and Krone et al. (1987) to relieve the understanding of the complete intra-organisational communication. As mentioned above, they are distinct by their different loci of communication and provide independent views on the topic. The four perspectives, mechanistic perspective, psychological perspective, interpretive-symbolic perspective, and systems-interaction perspective will be discussed in the following paragraphs (c.f. Fisher (1978) and Krone et al. (1987).

The Mechanistic Perspective

When analysing the communication from a mechanistic view the transmission process is the epicentre of the perspective. The locus as the distinct attribute is therefore the channel. That means that everything that occurs in the channel will be used as an explanation for the communication. With the underlying assumptions for the mechanistic perspective, quasi-causality, transitivity of communication functions, conceptual materialism, and reductionism, help to explain the perspective. The quasi-causality implies a linear connection between the communicators. It is therefore assumed that the source affects the receiver through messages send via the channel. The channel serves as a directional linkage. The second assumption, transitivity of communication, implies a chainlike relationship between several nodes of the communication. Each receiver becomes automatically a sender. This point out why breakdowns occur easily when a barrier blocks message transmission and reception. As the third assumption, conceptual materialism, the communication will be treated as materialistic. That implies a constant duration of time and the merge of channel with message codes like bulletin boards. Communication is conceived in tangible dimensions. The mechanistic framework assumes further that the communication can be broken into smaller units. This reductionism implies that it is easier to understand and deal with the concepts, if they are decomposed into smaller units. On these smaller units the assumption of the quasi-causality can be assumed. For the complete explanation of the mechanistic perspective some new and special components must be added to the basic components. These further components,
namely fidelity, noise, breakdowns, barriers, and gatekeepers, will be described with all new components of the following perspectives in chapter 2.1.3.

**The Psychological Perspective**

The psychological perspective focuses on the affection of individuals’ characteristics to their communication. Since as individuals we are surrounded of numerous stimuli, we automatically filter the subjective important to structure the potentially chaotic stimulus field. Consequently the conceptual filters become the locus of communication. These internal filters consist of attitude, cognition, and perceptions of the communicators and affect both *how* information is processed and *what* information is attended to, conveyed, and interpreted. Even if the assumptions of linear causality, transitivity of communication function, and reductionism are embraced, the communication is unlike the previous perspective not in the channel, but in the conceptual filters, they encode and decode information and stimuli from the environment. The other assumptions were summarised to internal cognitive processes of sender and receiver. The additional components of the mechanistic perspective can be adopted, but interpreted from message stimuli side rather than from the message transmission side. In the psychological perspective the description of the communication is limited to the input and output, since the conceptual filters are internal and therefore unobservable. The previous sender-transmission focus is subjugated to a receiver-orientation in the psychological perspective.

**The Interpretive-Symbolic Perspective**

Both the mechanistic and the psychological perspective assume that organisational characteristics determine communication processes to a greater extent than the communication process can affect the organisational characteristics. From the interpretive perspective, however, the organisational communication can create, maintain, and dissolve organisations. Rather than just passively using the organisation for transmitting the messages, the individuals within the organisation, by using communication, have the skills to create their own social network within the existing organisation and shape that. Thus, it is the most humanistic perspective and resembles symbolic interactionism, by assumptions about sheared meaning, and social behaviour. Hence, the locus of communication is role-taking and sheared meaning when discussing the interpretive-symbolic perspective. Role taking is to form mutual understanding with a peer group and also leads to the creation of sheared meanings for common actions. While both previous perspectives interpreted the messages in the channel or the filter, the interpretive-symbolic approach uses the mutual experience to interpret the
words symbolically. This interpretation cannot be done by isolated persons; it is reflected through social interaction and the mutual alignment with others. Behaviour is consequently not the response on the information stimuli, passed through the conceptual filters; it is rather learned and adopted by social interaction. Hence, it is changeable over time when the social context changes, but this is a very slow process. The result action can be distinct into three categories; nonsymbolic action, symbolic action and social action. Nonsymbolic actions are reflexes and require no interpretation before the action. The symbolic action is self intended. The individual interprets the message upon his own understanding. Social action is based upon the common interpretation of the message through social interaction. The additional components for the interpretive-symbolic perspective are defined as congruence and cultural factors and will also be described in chapter 2.1.3.

The System-Interaction Perspective
The focus for the system-interaction perspective lies on external behaviours and the overall communication system. Hence, the locus of communication is the patterned sequential behaviour. Instead of analysing the conceptual filters of the individuals or the shared interpretation, the grouping of sequences of communication is important. By stochastic probability the redundancy of the behaviour is ascertained and in a second step the patterns of message behaviour. Since the redundancy is the repetition over time, it is probable that a sequence of patterns will recur. It is not the single message that is salient; it is the sum or the pattern of sequences of messages. Here lies the main difference to the previous perspectives, the ones which were focussed on the single message. The communication process from a system-interaction perspective changes over time when the individual’s behaviour changes over time. That implies that not the individual is the central point, but rather its behaviour. In contrary to the active communication action in the mechanistic or psychological perspective, the system-interactions perspective treats communication as an act of participation.

2.1.3 Further Components
The four perspectives embrace the basic components described in chapter 2.1.1. But in order to explain the distinctions between them, it is necessary to provide some special components to the particular perspectives. The mechanistic approach requires for a field of further components – namely, fidelity, noise, breakdowns, barriers, and gatekeepers.
The Term *fidelity* means the extent of similarity of the message at two different points of the channel. The centre goal of the mechanistic approach is to achieve a high degree of accuracy between the message sent and the message received. But since a complete congruence is most likely not possible, the reasons for reduced information is referred to as *noise*. Noise occurs as interferences in the channel when the medium of travelling is disturbed or in the transmission process, when different processes for encoding and decoding the message are used. Similar to noise are *barriers*, i.e. obstacles during the transmission process that slow down the message flow. When the extent of barriers grows and the message flow along the channel stops completely, a *breakdown* occurs. During a breakdown, e.g. a cropped telephone cable, communication on this channel becomes impossible. Relatedly, when noise increases it becomes a barrier; and an increased barrier will cause a breakdown of the communication. The last new component is the *gatekeeper*; he is interposed between the sender and receiver of the message to facilitate the transmission process. When sender and receiver are unable to communicate simultaneously, the gatekeeper receives the information and relays them to the destination. When several sources try to communicate with one receiver the gatekeeper can act as a filter, and let pass subjective important information only. This filtering function will subsequently continue to all following receivers. For the psychological perspective the same components must be added to the basic components, but the interpretation of these will differ significantly. While the mechanistic is focused on materialism, transmission effects, and channels, the interpretation for the psychological perspective is justified with internal cognitive processes. For example, barriers and obstacles become a form of selective perception rather than physical hinderers in the transmission process. The interpretive-symbolic perspective requires congruence and cultural factors as new components. *Congruence* differs from the fidelity and similarity of the previous perspectives; it is rather a consensus in interpreting the different events than accuracy in transmission or the similarity of conceptual filters. The interpretation of symbols into meanings is affected by the context of the environment. *Cultural factors* will therefore have a strong impact on the interpretive process. These factors are the group’s way of thinking, feeling, and acting. The culture is more something an organisation *is* than what an organisation *has*. By knowing the way consensual meaning constitute culture, the organisation can govern the constitution of culture.

### 2.2 Organisational Impact on Communication

The organisation has several possibilities to influence the communication within itself. Organisational setting can support or inhibit. But also hardware facts as architecture have a
strong impact on the communication. And also individual preferences to communicate with sympathetic colleagues can be used by the organisation.

2.2.1 Impact of organisational structure

A first evident way to influence the communication or more specifically the inter-departmental communication is given by the organisational structure. The real goal of organisational structure is the structuring of organisational patterns to ensure communication. The structure consists of two types of organisation; the functional organisation and a product oriented organisation. Both structures have different, conflicting goals, and the organisation must meet both (Allen, 1977):

- Projects must be provided with state-of-the-art information in the technologies they rely upon. This is best accomplished through face-to-face communication.
- The activities of the various disciplines and specialities must be coordinated in order to accomplish the goals of multidisciplinary projects.

This trade-off between both characteristics leads to different organisational structures. The functional dimension is best to accomplish the first of the mentioned goals, while the product or the project orientation is favourable to accomplish the latter of the two goals. Here, one single individual is responsible for the coordination of the entire project. He pools the experts of the different departments to the department, so that they can discuss the interface problems with each other. The inter-functional communication will increase additively through the spatial bond. The project team is comparable with a functional department. But since the functional structure has advantages over the long term and in order to ramp up the production into higher volumes, the project teams were disintegrated after market introduction. In this organisational structure it becomes easier to tighten the production because there are only functional experts left in the departments, the intra-functional communication consequently increases while the inter-functional communication decreases.

In a hybrid form of organisation for projects, the matrix organisation, the project management is minimised to administrative and system level personnel. If disciplinary support or inter-functional coordination is needed specialists from all departments can be pooled together. This will allow better communication within the project without unduly sacrificing connections to the technological bases of the project. These temporal project groups appear often as inter-departmental meetings where accrued interface problems were discussed.
For the purpose of finding structures to prevent problems, the matrix is just conditionally useable, because only occurred problems were discussed and scheduled meetings are seldom in real time to the appearance of the problem.

### 2.2.2 Impact of informal interaction

In addition to the functional communication between employees a network of social communication also exists, according to Allen (1977). When a social contact between individuals exist, the probability for professionally-focussed communication is significant higher than without social contact. Those communications extend over the actual important topics and provide a more complete overview over organisations’ operations. In contrast to the organisational structures, given by the organisation, social networks are informal and the organisation has no power over the strength and intensity of informal networks. But since social interaction is a mechanism to promote communication, the interest of organisations to influence this important position of communication is significant.

The membership in informal groups is self-inflicted, but on the other hand the organisation already controls the informal networks, even if only through indirect means. The premise for social contact is to become acquainted with each other, and the organisation can create the necessary conditions. And management does control the composition of departments and inter-departmental groups. In those inter-departmental groups people from across the existing organisation, who might otherwise not meet, get to know another. The range of devices to influence the communication patterns through the development of informal contacts is wide, but while all increase the likelihood of improved communication, a guaranteed result is not given. As a matter of fact, the more enduring the contact is, as greater the effect. The result of a short seminar with organisationally or geographically separated employees will be much less effective than a temporary exchange as project teams. And a transfer to a new location will result in an even stronger and enduringly communication.

When discussing the communication related to the hierarchy or status of the employees an asymmetric distribution is found. While individuals of high status will tend to communicate frequently with each other, lower ranked employees will neither like nor communicate with one another as much. Consequently, low-status individuals direct their communication activities to higher ranked employees. This cannot be explained by the acceptance of work
assignments from the superiors, and since there is a lack of downward communication from the superiors there is no complete reciprocation. Organisations must provide interventions related to the low-status employees, that promote vertical communication, for both inter- and intra-departmental interactions. And interventions, related to the high-status employees, that encourages them to use the downstream link for both, professional and social reasons. For employees with the desire to move upwards, the upstream communication is a means to an end, even if it is not possible in the short run. Therefore the support of upstream communication is not as necessary as vertical or downstream. Most employees are intrinsic motivated to keep in contact with the higher-status ones. But if there is lack of possibility for upstream mobility, even in the long run, supporting interventions for the upstream communication is required.

2.2.3 Impact of architecture

When mentioning that organisations must create the conditions for individuals to meet one another, organisations can facilitate the appointments by organisational meetings or temporal exchange. A second possibility to facilitate the informal communication, and as a consequence an improved professional communication, is to design and establish appropriate physical spaces where the individuals can meet even without professional intention.

When measuring the distance between the communicators and the holding the frequency as constant, and aggregating the distances in intervals of three meters, Allen (1977) ascertained, with the specific individual as focal person in the centre, the graph given in Figure 2.
This measurement can also be performed for any frequency and for all available employees in the organisation. A well known result of this measurement is the probability of a pair of people in an organisation communicates at least once a week (Allen, 1977). The second variable was the distance between them. The results were plotted in Figure 3 and showed a hyperbolic, regressive curve, which reaches a low asymptotic level after the first twenty-five or thirty meters.

While the regressive, hyperbolic shape could be expected, the early begin of the asymptotic progression is startling. From a spatial view on communication, it doesn’t matter if communicators are thirty meters separated or more. An additional reason for the strong relationship between probability of communication and spatial closeness can be found in the fact that people that work on the same tasks together are more likely pooled together in locations near to each other. This will support the hyperbolic function of the curve, because for people without physical closeness and without similar work tasks the reason to communicate with another is rather low.
Since the likelihood of communication becomes higher as closer the persons are physically located to each other, the organisation must provide physical closeness between the work places. But is seems not possible to concentrate all employees in one office, even if this would be preferable. It still might be necessary for departments to be closely together as an entire unit; the departmental location is the centre of gravity from a professional view. But people do also have several centres, and if different departments do have the same kind of centres or the need for the same facilities, the organisation should establish common spaces for all departments. People could meet at these places and with lower distance between them, the likelihood for communication will increase.

2.3 General characteristics

We have seen that the different perspectives on communication lead to several possibilities to start interventions. Some more possibilities have been given in the organisational settings: the structure of the organisation and design of the workspaces. But still, communication has some more undiscovered characteristics. A complete listing will neither be possible nor convenient. In the past years characteristics of the channels have changed tremendously (Merten, 2006a)
and they will do so in the future. And a complete listing will not lead to significant useful information regarding the intra-organisational or inter-departmental communication of this thesis. Adolescent’s jargon will facilitate the communication between teenagers, but most likely not the communication for the purposes of this thesis. An enumerative listing of several dimension of the communication will follow, to display the most important characteristics. For each dimension, there is not only a black-white classification, the strength of the characteristics are continuously passing from one extreme the other extreme end.

**Personal vs. impersonal**

Face-to-face communication is one of the most known strength of personal communication. When discussing face-to-face, the personal character is obvious(Koch, 2006). On the other side of the scale there is the impersonal communication of mass-media to their clients. TV and radio shows broadcasting to numerous clients at the same time; the sender does not care if he has simultaneously one or one-million receivers. While the ratio for personal communication is $1:1$; the ration for impersonal $1:n$, with $n = \infty$. The area between the extremes can be described as $1:m$, with $m \leq n$; examples for those strengths are group meetings with a known number of participations (Merten, 2006b).

**Formal vs. informal**

Formal communication occurs, when people in an organisation are expected by the organisation to communicate with each other. This can be caused by the logical procedure of the processes or by scheduled meetings. The other extreme are informal communication interactions, those occur when employees with the same interests meet and discuss their informal topics. The informal communication adds a personal component to the professional interaction and people with a personal contact to each other are more likely to communicate without any reservation. It is therefore in the very own interest of the organisation to establish informal contact between their employees to improve the level of communication. The personal component during a professional communication interaction due to informal contact marks the transition from formal to informal communication or vice versa (Böhle and Bolte, 2002).

**Written vs. unwritten**

All communication messages must be transported from sender to receiver by a medium. The medium can transport the message either in a written or an unwritten manner. Letters, blank forms or articles are the most obvious manner for written messages; verbal communication is
the other extreme. The transition can be marked by written messages that are read to the receivers or by a written notice after a verbal interaction. The advantages for the written messages that are that the sender can ensure in advance to include all important points in his message, while the advantages for written memos are on receiver’s side, to ensure that he does not forget the relevant points. For reasons of documentation all results should be recorded, since spoken interactions are only recordable with available hardware, written interactions are easier to document (Fellenberg and Döring, 2006).

**Direct vs. indirect**

In chapter 2.1.3 one of the additional components were the gatekeeper, he was interposed between sender and receiver when they are unable to communicate simultaneously with each other. He buffered the messages until the receiver was available. If this occurs there is an indirect communication between the sender and the receiver via the gatekeeper. To answer he has to setup a new communicative interaction. If both, sender and receiver can communicate simultaneously a direct communication is possible. Semi-direct communication occurs if one accidentally gets access to a message that was not directed to him, not assume a criminal intent. If one accidentally drops into a discussion, he might get necessary information (Bruhn, 2005).

**One-way vs. two-ways**

If the partners do have the possibility to respond to the other one, they use a duplex channel of communication and this are the preconditions for a real communication with each other. If the receivers do not have the possibility to respond, the communication channel is a simplex one. This attribute is not a real communication, because there is no possibility to interact with each other (Bruhn, 2005).

This enumerative listing can not be complete for the reasons given at the beginning of this chapter. But it becomes more obvious that communication can occur with various characteristics, that all have an influence on it. Depending on the aims, different characteristics are more useful than others.

**2.4 Summary**

The components presented in chapter 2.1.1 and 2.1.3 gave a more complete picture about the facets of communication. The simple model of communication, Stimulus-Response-Model, developed by Aristotle, was esteemed as too narrow (Merten, 2006b) because the stimulus,
e.g. the information can be interpreted different on sender’s and receiver’s side. And also the changing character of the channel intimates that there is a need for a careful consideration while designing the components. Different methods of encoding and decoding of the message will be referred to the language or jargon problem discussed in chapter 3. But even the other components will need a careful consideration because even they have an influence on communication.

The four perspectives provide with their distinction by their locus of communication the new components, but with the locus of communication they also provide different views on the communicative interaction. The different concepts gave more possibilities how communication can be managed; with four different views a broader base for a synthesis of the views is given. E.g. the reductionism allows breaking the message into smaller units, this helps when the content of the message is difficult to understand. Smaller units might be easier to capture and to understand. The conceptual filters are the reason for the different priorities in the departments. It can be helpful to have different approaches for how information is processed in a company, but it is important to ensure the same filters for what information is processed. The locus shared meaning gave the first indications for an informal network within the formal organisation, and showed that since this group-interpretation is learned, it is also changeable. In the fourth perspective, the focus was on the behaviour of the communicators. This focus will be crucial for the subsequent chapters.

In chapter 2.2 the impact of different organisational settings on communication were discussed. The organisational structure has a major impact on the communication, because it is the framework for professional settings, but also the informal interaction contributes important aspects. The organisation must be aware of these and should influence them as far as it is possible. The architecture is on strong tool to direct the communication in a desired way. But not only structural aspects are to be considered but also informal. With respect to this, the architecture can enable the employees to come in contact with each other and establish informal contact. This informal contact can facilitate the professional communication.


3 Literature Research on communication management

After the first basic background on communication in general, it seems necessary to deepen
the knowledge about the special requirements for the communication between two or more
departments. The literature review is grouped together into four groupings that were deduced
by their general tendency. A fifth group includes two approaches that did not fit in other
groups. The articles discussed in the following chapters have been available to the author at
the beginning of the project. The articles were pre-selected by the project group as relevant
for the present group and analysed by the author regarding the categories effects on
communication and effects on the R&D-manufacturing interface.

3.1 Approaches to improve the new product development processes

In new product development, the most popular approaches are those concerned with
coordinating the phases before the market launch. The new development processes are most
likely stage-gate processes with a clear kill or go decision at the gates. The projects are
performed by cross-functional teams to ensure an early consensus (Cooper and Kleinschmidt,
1998).

Song et al. (1998) focuses on the product development process and investigate the joint
involvement of different departments during different phases of the product development
process. They divided the product development process into five stages and find variable
settings for the involvement of marketing, R&D and manufacturing, a comprehensive
representation of the results is given in Figure 4.

Involvement of all three departments at one stage is never productive. It can even be
counterproductive and so can the pairwise communication between two given function at
several stages. At some stages, a focal function will coordinate the communication. Here will
be no direct communication to the non-focal function; the focal function will be used as a
hub. That suggests that information sharing and coordination between the non-focal functions
can be indirectly implemented through the hub. Since the product development process is
different to the regular production these results are not easy to adopt. But it is important to
notice, that different phases require different needs of communication and that involvement of
all function could be counterproductive. The highest similarity to the regular process is given
in the last stage of the new development process, the launch. Here the joint communication
between manufacturing and R&D is productive, because the importance of a smooth ramping
up of the production to full scale is high. R&D and manufacturing can work out bugs more efficiently and effectively by cooperating during the launch stage. The involvement of marketing is neither significant nor effective; it is rather counterproductive for manufacturing and marketing. The negative impact of manufacturing and marketing is clear, because the production should be smoothed, further requests of the marketing at that stage will derange the smoothing process between manufacturing and R&D. Since only the involvement of manufacturing and production is significant productive there is no need for a focal function at this stage. The importance of the manufacturing-production dyad can be assumed as valid for the regular production.

Just as Song et al. (1998) discusses the relevance of joint involvement of different departments on the communication between them during the product development process, Adler (1995) puts his emphasis on the same part of the product life cycle where intra-departmental coordination mechanisms in ongoing operations remain relatively stable. Even if this stability is actually given, in the view of this study the mechanisms are too weak to ensure a sufficient communication. Nevertheless, Adler (1995) provides a practicable taxonomy to
improve the communication between R&D and manufacturing. The author acknowledges the relevance of the post release phase, when distinguishing the coordination possibilities in each of three phases. He proposed a pre-project coordination, a design-phase coordination and the manufacturing phase coordination. The second criteria for the taxonomy are different coordination mechanisms. Adler suggested four generic coordination approaches, non-coordination, standards, schedules/plans and mutual adjustment, and a team approach for the distinct coordination mechanisms. The taxonomy provides coordination mechanisms for each cell of the matrix. The non-coordination element of the manufacturing phase was characterised by workarounds: i.e. if the manufacturing met difficulties they just tried to find a way to handle them not to solve them. With the upcoming use of CAX systems (CAD, CAM, etc) the flexibility of the manufacturing increased rapidly. The new systems reduce the drafting time for incremental design changes and increase the quality of the output. The scheduled approach for coordination suggested an “exception” label for non-solved producibility issues and a schedule for the resolution was established. The fourth generic mechanism, mutual adjustment, provides engineering changes (EC) as a common form. EC is a probate tool to solve problems during manufacturing, but it is time consumptive and not preemptive by nature. The frequently described scenario: design throws the drawings over the wall and manufacturing sends back a list of required changes is a well known example for that. A team based approach for the manufacturing phase could be transition teams. Here, the design-engineers move into the manufacturing after the release. Design personnel are thus available for reviews. If they work in the team on a fulltime basis, it is more likely that they give reviews a higher priority than if they are when they are just attending meetings. This rotation was also seen as a way of developing design engineers’ understanding of manufacturing, which could be helpful for further projects. Adlers (1995) taxonomy offers a guideline to get coordination mechanisms depending on the phase. For the manufacturing phase the issue analysability should be low to work at the minimum of the cost of producibility. Issues with higher analysability should be solved in earlier phases. Depending on the novelty of the products or processes, the mechanism should be chooses. For low novelties standards are the most cost efficient mechanism, for high levels a team-based approach is preferable.

Analogically to Adler’s (1995) distinct use of mechanisms due to the phase of the product, Naveh (2005) suggested a tailored implementation of integrated product development. He tested the effect of cross-functional teams as a way for integration and coordination on
efficiency and innovation. The emphasis for the total new product development process should be different in the terms of implementation. At the beginning of the process the implementation should be applied to a lesser extent. The integrated product development process management approach lead to a higher efficiency, but reduces innovation, which is not desirable at earlier stages. The integrated product development process should be used more extensively in later stages of the project to increase the efficiency. With this fluctuation approach both efficiency and innovation can be gained within the process. In advanced stages a more structured orientation that applies standardisation, control and conformity to rules and procedures is preferred. This becomes clear because, in order to streamline and ramp up, the production is associated with the exploitation of already known facts about the production process, and an emphasis on integration within a organisation which focuses on manufacturing aspects, promotes conformity to rules and procedures, precision, and accuracy. These aspects are related to the product development process, but they deal with the properties of the regular manufacturing process. These properties, restricted to though deadlines and budgetary, are relevant for the assumptions that there is a strong need for standardisation and conformity to rules. They are not only valid in the pre-launch phase, but also during the regular production. We can also assume that standardised processes during after-launch are desirable and will have positive effects on efficiency. The integrated product development approach is a management approach that should improve project performance and coordinate these projects. An essential part of coordination is communication, therefore, if standardisation is needed for manufacturing, also the communication processes between during after-launch can benefit from standardised tools. The standardised tools should be used for the same communication partners that coordinate themselves in the project team during the development process.

Dröge et al. (2000) deployed a theoretical hypothesis with 14 firm-level practices that influence the ability of minimising development time and introduction time. These practises were grouped together into four main factors. A Varimax rotated four factor solution was conducted and supported the classification. The four factors were referred to as human resource management, synergistic integration, design-manufacturing interface, and supplier closeness. The relevant factor design-manufacturing interface included three practices at the firm level. These are concurrent engineering, i.e. the use of overlapping activities in product and process development; value analysis(product redesign, i.e. the synergistic investigation of a product to see how the design can be changed to improve the performance; and design
manufacturability, i.e. a proactive approach for effective assembly and manufacturing. These practices should eliminate delays, processing steps, simplify tasks and speed up operations. Surprisingly, the design-manufacturing interface did not have a significant influence on timing ability in introduction. But the authors hesitated to conclude the irrelevance of these practices and to ignore them. They refer to Wheelright and Clark (1992) stating that main advantage of DFM may lie in their ability to kill ideas for which manufacturing expertise does not exist. And although the factor is not significant, the practises can be significant correlated to the ability to minimise development and introduction time. Concurrent engineering evinced a correlation with the ability to minimise the introduction time. Furthermore, Dröge et al. (2000) admit that lack of significance may be due to measurement or specification errors. Or the loss of variance due to the creation of factor structures may cause the lack of significance. The constructs from the factor analysis are maybe to “macro” and therefore too far removed from crucial variables with a leverage effect on time ability. With consideration to these limitations, the three practises of the design-manufacturing interface factor should be born in mind for further considerations. And also the practises of the factor human resource, open organization, broad jobs, employee autonomy, and cross-training/job rotation should be considered. They are not directly focussed on the interface between design and manufacturing, but they facilitate communication and allow employees with processual knowledge to determine the best way of performing tasks.

3.2 Approaches to match the marketing-manufacturing gap

The first approaches for inter-departmental collaboration was done on the field for the cooperation between marketing and manufacturing. The mismatch between customer expectations and product features effected failures on the market. A closer involvement of both functions could overcome this gap. The efforts of these practises were significant and they became an important part of inter-departmental coordination. But there are also recent researches on the field which can provide new insights for intra-departmental communication in general, because they are intended to minimise the gap between the different views of different departments.

Balakrishnan et al. (1995) stated that it is non-trivial task for designers to determine an appropriate mapping between marketing and manufacturing. The task is to find attributes that generate the optimal product. They showed that underlying design philosophies can exist. These philosophies are guidelines to convert given marketing attribute into manufacturing
attributes. There are grouping concepts on the market and within them the products have a larger degree of commonality than to products in other groups. The groups are called design envelopes. For each group several attributes are prominent and provide clues for the design philosophy. With given inputs from the market, e.g. important attributes to the target group, the identification of a design envelope is possible. Since it is also possible to predict the manufacturing attributes for the envelope the approach save valuable designing time. The design philosophy approach shows, that a deeper understanding for the requirements leads to a higher success. Since philosophies and visions are long-term goals for organisations the philosophy acts as a structural guideline for the employees. It is a non-tangible goal and it could also transfer to the communication setting, even if it is much more difficult to explore the attributes for communication than the market attributes. But if the attributes are found with consensus, it is obliged for all employees to accept the communication attributes and behave in their manner.

While Balakrishnan et al. (1995) develop a philosophy that supports the coordination between marketing and manufacturing, Griffin and Hauser (1992) compare two team approaches and their effect on communication between marketing, engineering and manufacturing. They started with the proposition that communication between departments enhances the likelihood of success but it is difficult to obtain. Project teams should be able to reduce these problems, but they still occur. In order to identify new solutions the authors compared a traditional phase-review team with a Quality Function Deployment (QFD) team. The continued acceptance of QFD might be an evidence for enhance new-product success. Since they proposed the correlation between communication and success and since there might be a correlation between success and QFD, they conducted the comparison. The results showed that QFD increases the communication for team communication; however, the external communication is decreased due to QFD. Because the overall quality of QFD is at least comparable, QFD’s ability to tap internal information more effectively might be higher. This is supported by the suggestion that QFD leads to greater horizontal communication. The origin for the advantage may again be found in the elaborately pre-work in the house of quality. For the interface between manufacturing and R&D, this involves the translation of marketing needs into manufacturing features and vice versa. This stands for a consumptive work, because all needs and all features in both departments must be found. In the second step the marketing language must be translated into manufacturing language. Important is here again, as in Balakrishnan et al. (1995) state, the agreement on the interrelation. Once this
interrelation is established and the employees internalise them, they know, who to contact and how to ask, how to interpret respectively. But this presupposes, beside the pre-work, a behavioural change for the employees.

Both approaches for the coordination between marketing and manufacturing provide a structure that helps to understand the language and the way of thinking in the other department. With this deeper knowledge it is possible to translate the requirements into own features. If this knowledge could be internalised, the insight for the other function would grow beyond the primary intentions.

3.3 Factors with influence on the departmental interfaces

To improve the interfaces between departments it is important to know which factors do have an influence. The literature regarding these factors tries to analyse the interfaces, detect the factors and provide adjustments.

In their article about the R&D / production interface of 1986, Ginn and Rubenstein (1986) described the interface a key component for success in new product development. They proved their hypothesised assumptions for crucial factors with a quantitative field study. As a result of the case study the crucial factors can be named as: goals, power, uncertainty, imperatives, integration and marketing. These independent variables have a strong impact on the dependent output variables: organisational success, technical success and commercial success. But even if the interface is a key component, different structural patterns for both departments aggravate the interaction between them. While most R&D units are organic, decentralised, and informal in terms of their structure, the manufacturing units are rather mechanic, stable and centralised (c.f. Ginn and Rubenstein, 1986). Organic respectively mechanic describe a structure that is grown by his own demands on the one side and on the other grown as is was meant to be by instruction on the other side. The constitution of groups is a good example for that attribute. In centralised structures there is a strong hierarchy and only one head of the department. In contrary to that, decentralised structures have centres at different parts of the structure; the decisions can be made direct at the origin. Just as explicit as these two attributes is the third. While the structures in manufacturing are more stable, the structures in research and development are rather informal; the members work together and build patterns necessary for a smooth course. However, in the stable structures of the manufacturing, the workflow might be threatened if groups would change their constitution.
For the interface between both departments, a large potential for conflicts results from these differences. The different patterns also require different goals. For the production, the goal of special interest would be to maximise the output or productivity, subject to certain constrains. For R&D, the assumed goal would be to develop new products for introduction into commercial market. If these products do have new and complex processes this would tend to diminish the productivity, at least in the short run. Empirical studies in Ginn and Rubenstein (1986) prove that conflicts tend to arise due to different goals in two departments. The goals will create artificial barriers between the different departments and consequently hinder the global maximum although the goals should optimise the effort of both functions. Another cause for conflicts is given by high complexity. The higher the complexity the higher is the potential for conflicts. A super ordinate, common goal may overcome these barriers. This intervention is strongly recommended for departments with different goals, because it reduces the fundamental barrier of goal incompatibility. And in addition, if several departments have the same goal, they have to communicate with each other to tune their processes. Only with fine tuning they could maximise their overall result and their own reward.

Ginn and Rubenstein (1986) proposed model with a super ordinate goal for different departments which is applicable in both new product development processes and the following regular production. Song et al. (1997) commence at the lack of manufacturing involvement into the development process. While the most research discuss the R&D and marketing interface, Song et al. (1997) see the importance of manufacturing as given and state in a basis hypothesis that perceptions of the antecedents and consequences are similar for all three departments. From this it follows that also the barriers are similar. The authors state after their literature research five well known barriers and frictions related to the R&D—marketing interface: personality differences between functions (specially between technical and marketing people), cultural differences or thought-worlds, language or jargon unique to each area, organisational responsibilities and reward systems, and physical barriers such as physical distances between the departments can act as those barriers. It can be assumed that many of these obstacles are applicable to the manufacturing-R&D interface as well. But since these factors are only proved for the R&D—marketing interface, the basis hypothesis must be proven. The evidence of the validity even for the R&D-Manufacturing interface should be done by six hypotheses, namely:

- **H1:** External forces positively impact the degree of cross-functional cooperation achieved among R&D, manufacturing, and marketing in the NPD process;
• H2: Internal facilitators of cross-functional cooperation positively impact the degree of cooperation achieved among R&D, manufacturing, and marketing in the NPD process;

• H3: External forces positively impact the use of internal facilitators for fostering cooperation among R&D, manufacturing, and marketing in the NPD process;

• H4: Cooperation among R&D, manufacturing, and marketing is fostered more by internal facilitators than by external forces;

• H5: Cooperation among R&D, manufacturing, and marketing positively impacts new product performance in the market;

• H6: Internal facilitators positively impact new product performance.

If, in spite of the divergent functional goals, objectives, and reward systems, all three functions recognise the fundamental need for cross-functional cooperation, the overarching basis hypothesis would be proved. The hypotheses H2, H4, H5, and H6 are proved as valid; these internal facilitators were all found to positively impact the degree of cross-functional communication. However, the hypotheses H1 and H2 are insignificant. These external factors should have either an impact on the internal facilitators or direct on the degree of cross-functional communication. This could, according to Song et al. (1997) be caused by the fact, that internal mechanisms are issues on the operational level of organisational decisions and the external environment impact the firm at strategic-level decisions. With this explanation for the insignificant relationship of the external factors, the hypotheses suggest that perceptions of the antecedents and consequences of cross-functional cooperation are remarkably similar across R&D, Manufacturing and marketing, thus providing support for the basis hypothesis. If the basis hypothesis is valid, the barrier factors for the communication between the departments are valid, too. The reward systems and physical barriers are of organisational nature and can easily be changed; the language and jargon issues can be solved by practises like the mentioned design envelope philosophy or the QFD approach. They are on the edge between structural settings and individual behaviour, which means that even if the first results can be achieved right after the implementation, it needs more time to get the full potential. Personality differences and differences in thought-worlds are common and usual for different departments. While structural issues can be solved with an implementation, the personal differences need a change in behaviour. Behavioural changes are time consuming to achieve and require an extensive educational training. For the given barrier factors, some employees must learn to understand and act in that way, why other colleagues behave
differently and tolerate that behaviour without judging it. But if the behavioural change is achieved a sustainable will no doubt lead to further advantages.

Song et al. (1997) showed that factors influencing the marketing-R&D interface are also valid for the R&D-manufacturing interface by refining the basis hypothesis into six sub hypothesis and proving them as valid. In contrary to that approach Pagell (2004) analysed the integration factors on the internal supply chain with the special focus on the operations and two other key functions. After a field study they came up with propositions for enablers and inhibitors of the integration in the internal supply chain.

- **Proposition 1:** Top management support is required to create an internally integrated supply chain;
- **Proposition 2:** Information technology cannot increase the level of integration in a plant on its own;
- **Proposition 3:** In plants where functional managers do not have consensus on strategy, there will be low levels of integration;
- **Proposition 4:** As the amount of communication between managers in different functions increases, integration across the plant will increase;
- **Proposition 4A:** Real-time informal communication has a greater influence on the level of integration in the plant than formal, planned communication;
- **Proposition 4B:** As a plant increases the use of job rotation and or cross-functional teams the level of communication will increase;
- **Proposition 4C:** As a plant increases the use of job rotation and or cross-functional teams the level of integration will increase;
- **Proposition 4D:** Plants with facility layouts that enable/encourage managers in different functional areas to communicate informally will have higher levels of integration than plants where managers in different functions are physically isolated from each other;
- **Proposition 5:** The more a functional manager’s pay is tied to plant level performance the higher the level of integration;
- **Proposition 6A:** Plants with structures that create a mismatch between the flow of work and the flow of information through the system will have lower levels of communication than plants where the flows of work and information are matched;
• Proposition 6B: *Plants with structures that create a mismatch between the flow of work and the flow of information through the system will be more likely to have measurement systems that do not support plant goals than plants where the flows of work and information are matched;*

• Proposition 7A: *Plants with cultures that remove power from individuals and or pit individuals against each other will have lower levels of cross-functional communication than plants with cultures that empower individuals and or encourage collaboration;*

• Proposition 7B: *Plants with cultures that remove power from individuals and/or pit individuals against each other will place less emphasis on plant wide measures than plants with cultures that empower individuals and or encourage collaboration.*

As a main suggestion the author considered consensus as a key factor for integration and as a presupposition for consensus communication is necessary. The propositions 1, 2, 4, 4a, 4b, 4c, 4c, and 5 show interventions which are preferable to use while the inhibitors in proposition 3, 6a, 6b, 7a, and 7b of course should be avoided. In the Model of internal supply chain integration, Figure 5, the interrelations between the factors and the allocation of the propositions to the factors are shown.

![Figure 5: Model of internal supply chain integration (c.f. Pagell, 2004)](image)

Except of proposition 1 and proposition 2, which are basic factors, all propositions are allocated to the factors. The importance of consensus/integration as a key factor is highlighted in the model and also the importance of communication as a presupposition. The only factor without direct relevance to communication (i.e. no direct link to communication in Figure 5)
seems to measurements, but if measure systems are based on organisational goals, instead of functional goals, the communication will also increase.

All three approaches give possibilities to improve the collaboration between different functions and have a direct impact on communication. But even if there is no direct impact, the factor foster communication indirect. For this, the super ordinate goals and company-wide measurement system are clear examples.

### 3.4 Typologies and mechanisms for coordination

After having processed the factors that influence communication, this part of the literature research deals with coordination mechanisms that support the inter-departmental collaboration.

#### 3.4.1 Three-phases mechanism by Adler

A first coordination mechanism was given in Adler (1995). He divided the development process into three phases (pre-project, design, and manufacturing phase) and indicated various options for coordination mechanisms between R&D and manufacturing (non-coordination, standards, schedules and plans, mutual adjustment, and teams). The effects of the relevant manufacturing phase is already discussed in chapter 3.1, based on this typology Twigg (2002) developed his typology of inter-organisational coordination mechanisms. For the element of manufacturing phase and standards he postulated the earliest possible data release. In that way manufacturing can start earlier to verify the producibility of the design data. The data set do not have to be complete, the verification can also be proved incrementally. The design should also give some flexibility into manufacturing operations. Compared with non-coordination both aspects improve the collaboration. The second mechanism group, schedules and plans, is characterised by the use of production prototypes. Before the complete manufacturing plan is dispatched build test cycles on the prototype can verify the manufacturability. If changes occur after the final release of the drawings due to customers’ request, this will occur with a lot of rework and costs. In order to minimise this risk a meaningful and early implementation is preferable to bureaucratic check and balances. The inter-functional dialogue during the regular production is the post-project appraisal. Here the project data can be evaluated and the results are used beneficial for further projects.
3.4.2 Agent-facilitator approach

While these two approaches were topologies that help to find the suitable mechanisms for given product environments, Sun et al. (2001) provide a practice orientated mechanism for an enhanced collaboration between different departments. They recognise the importance of the involvement of all aspects during the development process. To achieve that it is important to gather and provide as much information as possible. Sun et al. (2001) develop a multi-agent system that integrates isolated and distributed systems as interacting agents. These agents communicate with each other by a mutually understood communication language. Even if the language in the multi-agent model is computer based, this postulation is valid for all communication partnerships. The language enables them to communicate direct with each other, but it is preferable to federate and buffer the information. A facilitator acts like a gateway between the agents and coordinates the communication. The agents are representatives of the departments and possess the complete knowledge about the database of the department. It is the task of the agent to provide the data to the facilitator. In the multi-agent system all designers and employees report and communicate exclusively with the facilitator. He decomposes the tasks and distributes the sub-tasks to the corresponding department agent. With the agent-facilitator approach, the costly direct communication between designers can be avoided and the data are still available for everyone at any time. Such a direct communication is ineffective and not feasible in larger organisations. In the system, each department carries out its own tasks and topics and provides all the data. The necessary communication is managed by the facilitator. The agent is a buffer for the data; data is submitted to the agent and stored there. If the information is needed, the designer can interact with the facilitator and gets the information from the corresponding agent.
Figure 6: System architecture (c.f. Sun et al., 2001)

In Figure 6 the procedure of the multi-agent/facilitator model is shown, the designer writes his data in a JavaWeb form and submits them via the design agent to the facilitator. The facilitator decomposes the tasks and distributed them to the departments. Even if the multi-agent/facilitator model is focussed on the interaction via a JavaWeb form, the interesting factors of that model are transferable to the interdepartmental communication: the facilitator and the databases of the departments. All data must be available all the time and must be up-to-date at any time; this task is fulfilled by the databases in the departments. The facilitator is the interface between all databases, he is aware of all the changes and other requirements that are shown in the data bases. By implementing this buffer possibility for the information, the direct communication between every single resource becomes unnecessary, consequently the dataflow can be reduced and the single employee is not overwhelmed with information. It is only important to provide the data to a free-access data base.

3.4.3 Concurrent engineering

For Paashuis and Boer (1997), concurrent engineering provides integration to the product development process. Concurrent engineering is meant to be an internally-consistent configuration of processes, technologies and organisational arrangements that is externally-consistent with corporate and market strategies; and leads to a match between market demands and performance of the product. They developed an operations strategy framework with integration mechanisms for different business strategies. They see three major definitions for integration, cross-functional co-operation, inter-functional communication, and process
overlap, respectively. Integration as cross-functional co-operation is the creation of synergy through the use of the different, individual skills. But since different departments are involved, the second part of the definition, the inter-functional communication must be heeded. And it is obvious that exchange of information is important and that the transferred knowledge or ideas can be used by the other function. If, due to early collaboration and communication, the process does not need to wait until the previous functions are completed, the third definition, process overlap is fulfilled. Now, Paashuis and Boer (1997) provide four facilitating mechanisms for collaboration, communication and overlap, namely: integration by strategic, process, technology, and organisational integration. Integration by strategic provides goals and strategies to achieve these goals. It is important to implement non-conflicting goals for the organisation and their processes. The goals will have considerable consequences for the organisation, first the choice of the product-market combination and second, technologies, arrangements, and directions to employees and guidelines for decision making. Other integration approaches are focussed on the processes; they are often used, but still poor understood. The integration efforts will have to be primarily directed to the function with the major impact on the given strategic goals. In most processes it is not feasible to integrate all activities. And mapping these activities is difficult, because there are no strategies available for a complete mapping strategy. So activities must be chosen carefully and after deep considerations, to find the adequate activities and functions. When speaking about technology in a broader sense, knowledge, experience, skills, methods, techniques, tools must be included. Those technologies are the third group and can be divided in three broad categories: humanware, software, and hardware; for these categories there are several ways of achieving technological integration. Humanware is concerned with experience and people skills and is related to aspects that let integration appear to be associated with people’s knowledge of activities in other departments; with social skills; and with the attitude towards cross-functional co-operation, collaboration and communication. Interventions like formal training, job-rotation or training-on-the-job can enhance people’s skills. Soft- and hardware related integration is the exploitation of all the resource available in soft- or hardware. Most tools have a really big potential but just a small part of it is used by the organisations. Common engineering data bases can enhance the communication and integration and are most often on-hand but still not used. By training and education for these practices, the available resources can be exploited more effective. Integration can also be supported by organisational arrangements. Arrangements can either be more or less durable, formal or informal, process- or product- orientated. All these characteristics for arrangements must be suitable to the
organisation and their goals and consistent within. The framework developed by Paashuis and Boer (1997) is focussed on the concurrent engineering as new in NPD processes. The individuality is seen in the integration, and since communication is one important part of the definition for integration, the communication related mechanisms of the framework are transferable for regular production.

3.4.4 Facilitating practices

The above described mechanisms can be used as a guideline to find some hints for useful interventions for improving the design manufacturing interface. Rusinko (1999) went even further, she tested the three types of design-manufacturing integration for their significance and positive correlation to the efforts of new product development processes. She views design-manufacturing integration as a special application of cross-functional coordination with the focus on differentiation between design and manufacturing. With the proposition that design-manufacturing integration facilitates product development processes and the definition of the integration by three practices the impact on the process effectiveness is tested. The three practices for design-manufacturing integration are found on the organisational level, the group-level and in integrative tools and techniques, see Figure 7.

Figure 7: Practices that facilitate design-manufacturing integration (c.f. Rusinko, 1999)
On the organisational level the practices try to decrease the differentiation between the departments but they do not necessarily include direct interaction between the two functions. Two interventions are tested and lead to two hypotheses:

- **Hypothesis 1**: Group-based evaluation will be positively related to effective NPD, and
- **Hypothesis 2**: A smaller number of levels to a common report for design and manufacturing will be positively related to effective NPD. (Correspondingly, a larger number of levels to a common report for design and manufacturing will be negatively related to effective NPD.)

The group-level practices can also decrease the negative outcomes of design-manufacturing integration, but they integrate two functions directly. Physical proximity can promote common experiences, which subsequently reduces potential conflict areas between the groups. Again, two interventions and their hypotheses are tested:

- **Hypothesis 4**: Rotating engineers between design and manufacturing functions will be positively related to effective NPD, and
- **Hypothesis 4**: Same site location for design and manufacturing personnel will be positively related to effective NPD.

While the previous practices reduced the negative outcome of the differentiation between the departments, integrative tools and techniques coordinate the interdependencies between them. Design-manufacturing integration manifests more reciprocal task interdependence and that must be coordinated through integrative tools to transfer the information between the departments. The tools and techniques codify and transfer this information, but they do not necessarily have a direct connection. The tools can also be some kind of a buffer or storage between the departments. Even for the third group of practices, two interventions and their hypotheses were tested:

- **Hypothesis 5**: Use of manufacturability guidelines by design will be positively related to effective NPD, and
- **Hypothesis 6**: Greater applicability of manufacturability guidelines used by design will be positively related to effective NPD.

The study showed significant and positive relationships for the hypotheses 1, 2 and 5. Therefore, the effectiveness is facilitated by practices that manage differentiation and coordination. All three interventions require no physical integration of design and manufacturing, they rather can be used for projects with a negative relation of physical integration and success. For the hypotheses 4 and 6 no significant relationship was found, so
these hypotheses cannot be supported. A surprising finding was the significant and negative correlation of hypothesis 3 with success. It was assumed that job rotation will have a positive impact in the success of projects, since this is also a well known intervention in literature and practice. Rationales for that can be summarized to lack of experience and diminished specialisation. The contrary to the mainstream in the literature suggests that the implementation of job rotation elements is not is easy as assumed. Regarding the job rotation other factors should be considered. The previous experience of employees in rotation or whether the product is a breakthrough or a derivate can have influences on the success of the product. In context with these problems intensive team training may teach the individuals to work effectively in cross-functional teams and together. The negative impact of job-rotation should not be generalised, depending on the project it can be minimized by several preparations. And also the fact that direct communication is not required and can be substituted by manufacturability guidelines for designer is notable and divergent from previous literature research findings.

The previous literatures on coordination mechanisms between different departments provide typologies to find the suitable mechanisms depending on the actual situation of the product either on the market or in the product life cycle. It showed also that different views on integration can help with different and new approaches that support integration.

### 3.5 Approaches with focus on individual behaviour

Two other authors were more focussed on the individual that is involved in the communication process. Blake and Mouton (1984) show possibilities to solve problems between already fighting groups, which should cooperate with each other. Priest et al. (1994) emphasise the need for educational training, even for employees, those possess educational skills and tacit knowledge on their field.

In situations, when group collaboration stuck because of inter-group conflicts, the positions of both parties frozen. Blake and Mouton (1984) identified two strategies for resolving inter-group conflicts. In their *interpersonal facilitator approach* a neutral person identified agreements and disagreements so that resolutions can be achieved. The *interface conflict solving approach* the disputants deal directly with each other and an external, neutral person helps only by providing a programme of steps to resolve their problems. In both concepts the neutral person has crucial role, therefore the choice of the person should be careful
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considered; as higher the involved parties are as more important it is for the neutral person to be from outside the organisation. In the first approach, the facilitator becomes involved in the discussions. He has an active part during the entire process. With different intervention strategies he keeps the discussion moving and builds a bridge between the contracting parties. The used techniques were described as:

- **Building anticipation**: he reports the main content of one part to the other in order to avoid the parties from overreactions during the meeting.
- **Controlling discussion**: he directs the discussions by authorising the partners to whom and when to speak and to answer, respectively. He controls the discussion so that none spoke without permission.
- **Reversing antagonists’ role**: he helps both parties to understand and clarify antagonists’ role by formulating their understanding with their own words and conformation of that statement. It is now possible for both sides to know the real understanding for the antagonist.
- **Relieving tension**: when meetings stuck because of strong formulations and the opponent tends to block against the statement, it is by the moderator to relieve the tension and help to move forward.
- **Transmitting information**: when groups act as rivals, they tending to minimise the communication between each other. It is by the facilitator to convey the statements between the groups to ensure a minimum of communication; he can prevent the process from breaking down.
- The last technique is the **formulation of proposals** to the antagonists. After listening to the situation and to the statements, the facilitator can draw conclusions without being burden of deep involvement. These unemotional proposals are most likely more efficient than emotional ones.

The central role of the interpersonal facilitator process is the facilitator He acts as a moderator and is full-time involved in the ongoing discussions. He also carries messages and information from one side to the other and helps the process with proposals. The approach is extremely practical for situations with only two involved people and a near deadline. In contrast to that, the interface conflict-solving model is focussed on groups which should develop the solution together without major involvement of the facilitator. But since groups are involved in the solutions process, they need time to find the solution for the problem whose depth and scope is unknown. Blake and Mouton (1984) propose a five-step model,
which should be supervised by the administrator. In the first step, each group should meet separately and prepare a presentation of their view on the problem, during the presentation, the speech is by the spokesman and the others must keep discipline. In the second step, the groups, again separated, identify similarities and differences. Then the actual conditions should be described and later consolidated to a common statement of the situation. If a common statement is given, it seems possible to identify steps for a solution process together. The moderator has a more passive role during the process. He ensures the ongoing of the process and the discipline of the members, and answers any questions about the procedure. His role is to set expectations of objectives and activities at each step. He also establishes ground rules for the general sessions and determines the sequence. So, he reminds all members to ask their spokesman for speech and establishes the sequence and duration of the spokesmen. Besides, he monitors for candour to ensure openness and he intervened against rule breakers when they showed hostile attitudes. It is not the task of the moderator to evaluate the progress; he is rather expected to introduce procedures to reduce disagreements when the groups reached a dead-end. The last two interventions for the facilitator were ensuring understanding and follow up. Since it is important, that audience grasp the same meaning as the speaker, the facilitator encourages the audience to formulate their understandings and ask for open points. And since all discussions are meaning less as long they don’t end in actions, he helps to set a follow-up schedule to ensure the implementations of the results. Both approaches support the implementation of a third party to facilitate the communication. While Sun et al. (2001) saw the facilitator as a computer interface, in Blake and Mouton (1984) the effectiveness depends on the personal skills of the facilitator. For the case of the design-manufacturing interface the interface conflict-solving model is more suitable, because the entire department can be involved. And the emphasis on the importance of the understanding for antagonist’s point of view as a starting point for further solutions highlights the individual aspect of the approach. Not before a common understanding is established, a solution can be achieved.

While Blake and Mouton (1984) emphasised the individual skills of a facilitator to overcome inter-personal and inter-group problems, Priest et al. (1994) recognised the personal skills for the new requirements in cross functional teams as crucial for the competitiveness. With a questionnaire they asked employees for the most important sources and contents for the new interdepartmental requirements. The most important contents were detected as design process, hands on design, producibility and technical management tied with system integration. The
respondents saw the need for deeper education on these fields. As a source for this knowledge more than 50% of the respondents saw the responsibility by corporal training activities, only a small fraction of about 3% saw the universities as responsible to teach the engineers these facts. The rest saw both institutions responsible for the education. These findings are not surprising because the actuality of knowledge is important but transient. Organisations must ensure that their employees do have the actual state of the knowledge available at work. But even if the employees recognised the responsibility of the organisations, there is a fatal lack of it. Over three quarter and over the half of the respondents recognised a lack of corporate training and corporate on-the-job training, respectively. They desired as important for corporate training concepts and engineering methodologies like design policy (i.e. production innovation), configuration control, subcontractor control, and technical risk management. The desired concepts for the on-the-job training were identified as parts and material selection, design reviews, design release, test-analyse and fix, field feedback and technical risk management. Since the concepts in both categories differ from each other it seems necessary to provide both methods to the employees. While the desired methods for the corporate training are more controlling and supervision focussed. The training on-the-job methods are more focussed on aspects of the actual production process. Priest et al. (1984) proved in a quantitative study the general assumption, that ongoing training during the working life is important. The academic education seems to be incapable to provide this necessary knowledge alone. The enduring learning process, either in theoretical training activities or more practicable training (i.e. on-the-job activities) is indispensable, should rather be provided by training. The training can provide the knowledge alone or in a combination together with the universities. But both institutions must change their range of activities that could be used in practice, there is a large range needed for changes and according to the study, the respondents would change both.

Blake and Mouton (1984) were focussed on the importance of individual skills to overcome warfare between groups and individuals. A skilled third party is capable to solve stocked situations and to tighten the emotions. The mentioned techniques are also advantageous to prevent warfare. These skills concern the interpersonal contact related areas. A second way to improve the operations with improved individual skills is exposed by Priest et al. (1994). In contrary to the previous one, they saw the solution not in preventing the interpersonal problems, but in deeper knowledge about the processes. If the worker’s knowledge is not limited to their own area, but also to those of the upstream and downstream departments, the
inter-departmental collaboration will be enhanced significantly. Since all knowledge lose their actuality, it is important to provide ongoing training. The study of Priest et al. (1994) showed that corporate educational training and corporate on-the-job training are extremely efficient.

### 3.6 Results

One of the most important findings in the literature research is the result of Song et al. (1997), they proved that the factors for the interface between marketing and R&D are also valid for the interface between R&D and manufacturing. With this result it is possible to transfer all the findings for the marketing-R&D to the R&D-manufacturing interface. This includes the well known language or jargon problem between two departments. Griffin and Hauser (1992) and Balakrishan (1995) showed that the QFD model and the philosophy envelop model, respectively, can overcome these language or jargon problems. Pagell (2004) showed that high performance on the plant level can only be achieved by consensus and integration of the different functions. He exposed the importance of communication as the main influence on integration. Job rotation, open plant layout, cross-functional teams and informal communication can enhance communication. Top management support is an antecedent as well as a crucial factor for integration which can not be substituted by information technologies. He also stresses the significance of super-oriented goals. In the literature on new product development the regular production is just the last part of the entire process and even if the crucial cross-functional teams are dissolved after the ramp up of the production, the transfer of the results to the regular production is possible. Naveh (2005) supposes the structuring and the standardisation of the processes to improve the integration. Song et al. (1998) tested the result of different integration levels to the efficiency of the process. A complete integration is not useful, but during the manufacturing phases the integration between R&D and manufacturing is effective, the integration of more involved parties is here counterproductive.

Dröge et al. (2000) identified four factors for the minimising of introduction and development time; this implies an improvement of the process. With the structure of organisations the time can be minimised by implementation of open organisations, broad jobs, employees’ autonomy, and cross-training or job rotation. Computer aided design or engineering, group technologies, standardisation and cross-functional teams for innovation can enhance synergistic integration and consequently time minimising. The third factor, supplier closeness, is not related to the design-manufacturing interface, but this by its own is the fourth factor.
Concurrent engineering, value analysis or product redesign and design for manufacturability are items for that factor. Adler (1995) reported several mechanisms to improve the coordination; he punctuated the scheduled review of non-accepted drawings. But since this is time consumptive, an integration of the design engineers into the manufacturing will be preferable. The design engineers will move to the manufacturing in order to discuss problems immediately. Based on Adler (1995), Twigg (2002) constructed a typology to find the right mechanism depending on the phase of the life cycle. Sun et al. (2001) developed a mechanism to minimise the inefficient and costly direct communication. They installed a facilitator as a gateway between the different designers. When a task was initialised, the facilitator decomposes this and distributes the sub-tasks. All departments store information about their facilities and skills, the facilitator has access to this information and uses them for the decomposition. Paashuis and Boer (1997) saw concurrent engineering providing integration to production processes. With three different views on integration, cross-functional cooperation, inter-functional communication and process overlap, they developed mechanisms to support the integration. These integration-by techniques, strategic, process, technology, and organisational settings, support the integration process. In terms of strategic, they punctuated the relevance of non-conflicting goals; these will have impact firstly on the product-market combination and in second order on the guidelines. Regarding the process integration it is important to map the relevant activities and focus the integration on them. The technology can support the processes by exploiting the resources of software and hardware. The organisation can support the processes with the suitable choice of durable or non-durable setting, formal or informal flows, a product orientation or a process orientation, and consistent goals.

Rusinko (1999) perceived three mechanisms with influence on the effectiveness. These design-manufacturing interface mechanisms are found on the organisational level, on the group level and in integrative tools and techniques. She found significant positive relations for a group based evaluation, another evidence for the significance of super-oriented goals, the minimisation of levels and the use of manufacturability guidelines. She also found a negative correlation for the implementation of job rotation. While job rotation is one of the most recommended interventions, the study showed that negative impact. The lack of experience for employees could cause this effect. The contradictorily predictions to job rotation involve at least a careful consideration before an implementation; it can not be seen as a panacea. Another contradiction to already known statements is substitution for physical integration by guidelines. While others highlight the importance of closeness and of informal contact,
Rusinko saw the substitutability by information technologies as a way to overcome physical separation. The guidelines are the rules for the communication in terms of schedules, contents and participations.

The individual character of the communication was stressed in Blake and Mouton (1984) and Priest et al. (1994). The first stressed the individual skill to overcome warfare between groups or their leaders. The interpersonal facilitator is a third independent person who acts like a moderator between the leaders, he communicates with the antagonists to prevent negative reactions during the meetings. He becomes an active part of the discussion. In the interface conflict solving group, the third person acts more like a supervisor or referee who cares about the before assigned rules. In contrast to the interpersonal facilitator he will not participate active in the problem solving process. The second skill focussed approach is given by Priest et al. (1994). They emphasised the personal skills regarding the actual process. A deeper knowledge in all processes, also the procedures in other departments, will lead to a higher efficiency of the processes. Since the actual education programmes are not competent to teach the required skills, the curricula must be changed. The study result showed that corporate training, either educational training or training on-the-job, is more effective than merely academic education. A combination of both is also advisable.

Numerous authors on the topic have a scientific background at universities world wide. Even if they report about practical implementations, communication setups, and coordinative structures for cross-functional collaboration, the researchers are not working in those environments. They report as independent observers about the companies, for their studies they just have experience for several months or weeks in the companies. At the actual moment there is no study known, that is written by an author who actually works in such an environment. It might be interesting to know more about the direct experiences of employees working with advanced inter-departmental communication setups. The lack of those studies might be due to the fact that the primary interest of companies lies in the implementation of new strategies and less in the development.

This tendency rises also in the target group of the authors. The majority of the authors are focussed on managers who show their interest in the implementation of new strategies. For that reason strategies are presented to implement the new philosophies. But of course the literature discloses some further opportunities for managers. In contrast to that, Balakrishnan
et al. (1997) address to the design engineers, because they realized the importance of the right placement of the product on the market. A similar approach was described by Adler (1995): practitioners should use taxonomy to coordinate their interdependencies in the most efficient way. In Priest et al. (1994) the emphasis was focussed on educational programmes and teachers at universities and trainers for corporate training were the target group. They should develop new training and teaching methods that are adapted to the new requirements of cross-functional teams. A complete different target group was focussed by Blake and Mouton (1984). While all authors demand either a scientific or a professional background, Blake and Mouton (1984) succeed to address a wider audience. By describing an illustrative case study without any pre-knowledge, they addresses also to non scientific readers. Such a wider approach would be desirable for further studies in order to reach explicitly the workers without any scientific pre-knowledge.
4 A questionnaire to ascertain the actual state of intra-organisational communication

The complete questionnaire created and used for this thesis consists of two parts. In the first part of the questionnaire, the actual state of communication within the organisation was ascertained to learn more about the communication patterns. In the second part the opinions and the attitude toward the interventions was queried.

Since the thesis is part of the HELIX project communication specifications and experiences between product design and production, the employees of the HELIX partners BT Products Inc., SAAB Inc., and Siemens Turbomachinery Inc. in the departments concerned were asked to complete the questionnaire. Other organisations and other departments would also be helpful, but the support should be directed to the HELIX partners.

The questionnaire was performed as a web-form, but the employees were directly addressed by email to complete the questionnaire on a given web address. The contact to the employees was enabled through the contact persons that represented their companies in the meetings of the project group. They were asked to contribute email addresses from both R&D and production. When these addresses were available, the employees were directly asked. The questionnaire consists of open questions, where the person asked fills in his/her answer in numbers or words, and also check boxes on a 5-point Lickert-scale and simple yes-no questions, respectively. Examples for open questions and yes-no questions are shown in Figure 8, the complete first part of the questionnaire is shown in Appendix A.

Figure 8: Example of yes-no question (2) and an open question (3)

### 4.1 Intention of the first part of the questionnaire

Communication within an organisation can appear in various manners, but the focus of this thesis lies in the inter-departmental communication. Therefore it is the main intention to get
more information about the actual state of inter-departmental communication. But to draw conclusions from the state of inter-departmental communication it seems necessary to compare it with other communicational relationships. From the previous sections it could be expected that the intra-departmental communication is on a significant higher level than the communication for the relevant communication between R&D and manufacturing. But a comparison seems also essential to see if the intra-departmental communication could support the relevant relationship with their actions; either direct or by transformation from intra- to inter-departmental communication. Those transformations could also be performed on elements of the communication relationship to any other department; therefore organisational wide communication behaviour is also of interest.

4.2 Structure of the first part of the questionnaire

The first part of the questionnaire to ascertain the actual state of intra-organisational communication consists of five sub-categories. The first two categories are focussed on the demography and general opinions toward communication of the persons asked. The last three sub-categories are addressed to the intra-departmental communication, the communication between the R&D and manufacturing units, and the company wide communication, respectively.

The demographic questions ask for the age of the employee and his duration in the organisation. Since the communication channels changed enormously during the last decade, it is interesting to know if it is easier for younger employees to adapt to these new channels than for older ones. If it is so, the organisation should prepare those employees with a more sensitive training for the changes to diminish the fear of those. The question for duration in the organisation could give some clues of the usage of informal communication or the tacit knowledge about it. If the level of communication increases significant with the duration in the organisation, the importance of informal communication is high and the organisation should improve their structures to support the formal ways. The formal ways are important for newly-engaged employees, because they don’t have the time to gather enough knowledge about informal processes.

The general questions ask for the personal understanding of communication and a description of the own departments’ role within the organisation. If major differences between the view of the employee’s view and that of the organisation occur, an adjustment becomes necessary.
The view of an employee that his work is independent from the work of his colleagues and that they do not base on his results would be really harmful for the organisation.

After these demographic and general questions, the communication regarded questions follow. For each constellation, intra-departmental, between R&D and production, and within the entire company, respectively, a set of basic questions were asked to enable the comparison, but also some additional questions.

It was first asked for the departmental goal or rather if the goal is known, when speaking about other departments. As it became obvious in previous sections different goals within an organisation will not lead to the overall maximum. For similar goals and also for different goals, it is important to know how these goals are measured, this was asked in the subsequent question.

The next basic questions treated the frequency and the duration of communication. This is one of the central questions, because it allows a real quantitative comparison of the communication levels. As higher the frequency and as longer the duration of the communicative interactions are, as better the communication level between sender and receiver is.

While these questions were easy to quantify, the subsequent questions were rather of qualitative nature. The questions for content of the communicative interactions and the level of complexity can not be measured with a common scale, but even the subjective measurement is important, because complex topics are more likely discussed in personal than in impersonal contact.

The next question aimed to standardised procedures for communication activities. In most industrial settings, standardisation is one way to ensure a wanted level of quality. This is valid even for communication; a first approach to ensure communication is to establish standards and if organisations established that it was asked for a description of it.

The last two questions were again more of quantitative nature. First it was asked for the channels used and their frequency and afterwards for the reason of communication, again with the frequency. By knowing the channels the preferred way of communication could be limited and the reasons of communication will get information if the actual communication is proactive or reactive to problems.

In addition to these basic questions, for the communication within the entire company it was asked whether other departments than those are in communicative contact and with which strength of the contact. While investigating this, a communication pattern within the company
A questionnaire to ascertain the actual state of intra-organisational communication could be established. A communication pattern could be helpful to identify stronger and weaker relationships and to draw conclusions from the stronger relationships to improve the weaker ones.

4.3 Results of the first part of the questionnaire

The main intention of this first questionnaire was to find existing correlations between the used channels and personal parameters. The results were investigated to find correlations between the age, the job tenure in the organisation of the employees, and the complexity of the message against the channels used for communication. These investigations were done for all relationships, intra-departmental, organisation wide, and between design and manufacturing.

4.3.1 Correlations between age and used channels

For the parameter “age” (see Appendix B for the data), a correlation was neither evident within the own department, nor for the organisation-wide communication. For the communication between design and manufacturing on the other hand, the Pearson-coefficient for the relationship between usage of spontaneous meetings and age resulted to 0.877. This correlation was tested for significance; after a Fisher-transformation and a standardisation, a significance level of 99.68% was given. The result is plotted in Figure 9.
4.3.2 Correlation between complexity and used channels

The data was further tested on a correlation between the used channels and the complexity of the communication content (see Appendix C for the data). While there was no correlation for the communication between any departments company-wide, there was a correlation within the own department against the frequency of emails used (see Figure 10), and one for the communication between design and manufacturing against the frequency of used intranet (see Figure 11). The Pearson-coefficients, -0.923 and 0.858, respectively, have been tested with the same calculations for the level of significance. Both resulted to be significant, with a level of 99.93% and 99.50%, respectively.

![Figure 10: Correlation between the frequency of emails used and the complexity of the message for the communication within the own department](image)

Figure 10: Correlation between the frequency of emails used and the complexity of the message for the communication within the own department
4.3.3 Correlation between job tenure and used channels

Furthermore the data of the job tenure of an employee and the frequency of used channels was checked for correlation (see Appendix D for the data). The obtained Pearson-coefficient on the organisation-wide level had a value of -0.895 (see Figure 12), with a significance level of 91.63%. For the correlation for communication between design and manufacturing for the job tenure in the company and spontaneous communication only a Pearson-coefficient of 0.677 was reached. Since a correlation with the age of the employee could be shown, a correlation with the duration was also expected.
4.3.4 Further Results

The first part of the questionnaire also investigated the data about a possible correlation between the job tenure in the organisation and the absolute frequency of communication, but for neither relationship, intra-departmental, organisation-wide, or between design and manufacturing, a correlation was evident.

The question asking for the goals of the departments showed that none of the organisations had established a super-oriented goal for the entire organisation. All departments were aiming to their own goals.

Further interesting relations, communication patterns between the different departments and differences between the participating organisations, could not concluded from results of the present questionnaire. Weaknesses in the structure of the questions or the weak response rate could be rationales for that, which will be discussed below.

4.4 Discussion of the first part of the questionnaire

4.4.1 Discussion for the correlation between age and used channels

The in chapter 4.3.1 investigated correlation between age of the employee and the used channels showed a relationship with spontaneous meetings as the channel. But this correlation is not caused by the job tenure in the organisation as it was expected. The results in chapter
4.3.3 showed a weak negative correlation. The reason for the increasing usage of spontaneous informal communication with increasing age must therefore be found in the personal skills, for example work experience and life experience of the employee that grow with the age.

4.4.2 Discussion for the correlations between complexity and used channels

Two correlations judging the complexity of the message have been obtained in chapter 4.3.2. Between the use of emails and the complexity of the messages on an intra-departmental level the negative correlation seems to be self-explanatory. The more complex the content gets, the more difficult it gets to write it in an email. If the employees are working together in the same department, it would be easier to communicate without email. However, the email is not substituted by a personal face-to-face communication, the weak correlation between complexity and face-to-face communication is also negative. The strongest positive correlations, but still below 0.7, were measured for communication via boards or intranet-websites. This could be the fact, that growing complexity of a topic might be result in more uncertainties by the employees. The communication via board or intranet enables a larger distribution of the messages, while keeping anonymity.

The positive correlation between complexity and the channel intranet for the communication between design and manufacturing is another proof for these observations. Again, the increasing complexity is the rationale for the use of this anonym channel with its good possibilities of distribution. Also, the two departments are most likely not located close to each other, the intranet seems to be the adequate channel.

The intranet as a communication platform seems to be the best channel to manage complex contents, since more colleagues can see the topic, more answers can be expected.

4.4.3 Discussion for the correlation between job tenure and used channels

As shown in chapter 4.3.1 the frequency of spontaneous communication and increasing with age is significant. It was expected that this strong correlation was caused by their longer duration in the organisation and the fact that they therefore knew more colleagues. So the correlation between job tenure and used channels was investigated in chapter 4.3.3. Since the results for this relationship showed no correlation (only with a coefficient of 0.677), this assumption was negated.
4.4.4 Further discussions

The different goals for the different departments have, from the view of the employees, no impact on the communication between the departments. But as mentioned in the previous chapters, other studies (see Ginn and Rubenstein, 1986) showed the positive impact of a super-oriented goal for the communication and collaboration between departments. Besides, a common goal for the complete organisation leads to a higher overall output than the sum of the sub-results. Since the employees are not aware of this artificial hinder, the organisations should provide educational trainings explaining the relevance of common goals within an organisation and should implement a common goal, even if the employees do not see its necessity.

Further results were expected from the questionnaire. However, since the questionnaire was a first-draw without any previous experiences in the practice, some structural weaknesses could not be obviated. Some questions seemed to confuse the persons asked, as the questions for the communication pattern showed. A different order of the questions or different verbalisations of the questions could result in more valuable answers. The experiences of this testing would give some valuable information. The response rate was extremely low, which was unexpected, that complicated the analysis of the data. Over twenty employees in three HELIX partner were asked to complete the questionnaire, but despite the cooperation with the contact persons of the HELIX project group, only seven responses from only two organisations were received after a period of five weeks and one reminder. Since the partners have their own interest in the topic, it was expected to see this interest in a higher response rate. With this small number of answers just one outlier could falsify the result. With more answers the relevance of the significant correlations would extremely increase.
5 Framework for an improved communication interface between R&D and manufacturing

The main intention of this thesis is to develop a framework for an improved communication setting between the departments of R&D and production. This framework should also include an implementation approach for the new communication interface. In this chapter three approaches are presented that are useful for an implementation process, but they seem contradictorily with each other. A strategy for organisational development will overcome this problem and provide a continuous approach for the implementation. This approach will be equipped with interventions that support a better communication between the departments.

5.1 Approaches for organisational changes

In the literature of organisational changes there are numerous different approaches of sources that can cause an organisational change. Pierce and Delbecq (1977) identified three different perspectives from that an organisational innovation can be derived. They saw as the most prominent model the deterministic structure. But the origin for changes can also be seen in the values and attributes of the member or in an interactively influenced relationship between both structure and membership. In a more recent article, Slappendel (1996) used the three perspectives as a framework and highlighted, beside the actual dominance of the individualist and structuralist perspective, the upcoming weight of the interactive process perspective.

5.1.1 Individualist approach

Slappendel (1996) sees in the individualist approach the major source of change in the individual. And the individual is not constrained by any external factor, it acts completely self directed; as a precondition, the individual is rational and value maximising is the decisive factor. It can therefore be assumed that individual traits are essential for the individualist perspective. If individual traits are decisive, differences between the employees will occur because not everyone will have the same impact of innovative behaviour. Van den Ven (1986) recognised this and stated that some individuals can introduce innovation more easily than others. This implicates that human capacity to handle complexity and non-routine issues are different and limited. Consequently some individuals are more resistant to the implementation of innovation than others. But it is common for all individuals that, as long as they do not recognise a performance gap, i.e. a discrepancy between satisfactory and actual performance, there will be no increase in the rate of innovation (March and Simon, 1958).
The actual performance is largely affected by the routines and repertoires. The employees are used to these individual skills and not willing to change their behaviour without seeing any benefits from it.

### 5.1.2 Structuralist approach

The difference between the individualist approach and the structuralist approach is for Slappendel (1996) that the individual approach seeks for characteristics and actions of the organisations members to explain the behaviour necessary for innovation. Instead the structuralist approach emanates from the view that innovation is determined by organisational characteristics. These impersonal mechanisms act as external constraints to shape the organisational behaviour. All the organisational sub-systems can act as those mechanisms. Since these mechanisms cannot only be found in the organisation but also in the environment, the structuralist approach overcomes the main disadvantage of the individual approach merely focussing on the individuals’ character, with paying attention to the interrelation of the organisation and the environment. But it considered technologies and strategies as given and assumed that individuals act rational.

Structure variables like size or centralisation of the organisation, complexity of the tasks, professionalism of the employees, and formalisation of the job are found to have positive relationships to innovation, but beside of the size of an organisation, negative impacts are found for all variables. Even the size itself is not a necessity, it is rather important in terms of its indirect effects on organisational structure. Due to this problem of contradiction, Wolfe (1994) suggests contingency models for different types of innovation processes, types of organisations, and for different stages of the innovation process. Zaltman et al. (1973) developed a contingency theory with two main stages. During the initiation stage the gathering and processing of information is crucial. This is supported by low formalisation and low centralisation. Whereas, the implementation higher levels of formalisation and centralisation should be achieved. That in turn requires the ability to shift the structure of the organisation. The initiation is more likely to require an organic structure, the implementation a more mechanistic structure.

Both the individualist and the structuralist approach are focussed on one key determinant of the innovation process, either the individual or the structure. It seems therefore logical to contemplate the interactive process approach of both.
5.1.3 Interactive process approach

The two stages approach from Zaltman et al. (1972) seems to be too static. A more dynamic, continuous conception of change over time could be accomplished by the interactive process approach. The interactive process is rather a change of discrete states over the time than the implementation of an effective cause that has proven his efficiency in other implementations (Slappendel, 1996 cites Mohr, 1982). These states are either related to actions of the individualist approach or to actions of the structuralist approach. But since both approaches have a paradoxical relationship to each other, it must be investigated how these action do interrelate to each other. This understanding represents the difference to the previous approaches but there are still problems to merge both. Van den Ven and Poole (1988) suggest four ways to reconcile them. The two most practical suggestions are firstly to use both approaches just as two different perspectives to get different views on the same situation, and secondly, to associate the different levels of interaction with different phases during the process; time could give the relation between them. Slappendel (1996) found illustrative aspects that are intercessional for the interactive process approach. The assumption of the rational economic model must be rejected by non-rational aspects of decision making. It is also discerned, that innovations do not remain static during the implementation. They are rather dynamic and transformed by it.

5.1.4 Conclusions from the approaches

The solely focus on one perspective, when applied in their purist form showed major disadvantages and advantages for both. This led to the assumption that they are incompatible or contradictory. The analysis of only on perspective could not end in an adequate analysis of the complex interrelation of innovation because only one pert of the picture was treated (Slappendel, 1996). Therefore, the total incompatibility and the mutual exclusiveness could not be concluded. The growing interest of the innovation process led to a synthesis and integration of the individualist approach and the structuralist approach on a continuous time-frame.

Instead of using either the individualist approach or the structuralist approach, both should be involved; instead of using a rigid model for the interdependence between the approaches, the interactive process approach requires a flexible time-frame between the purist forms. An initial stage for a solution is presented in the following chapter.
5.2 Implementation of organisational development

Organisational changes are manifold (Porras and Robertson, 1992), they can occur either in a planned or in an unplanned manner. They can also be sectored in orders; in the first-order, the change is a linear and continuous alteration with still valid cause-effect relationships and basic paradigms. In terms of this thesis the change is of planned and first-order nature, the combination of both is qualified as development. Organisational development can further defined as planned behavioural and technique based intervention to alter the on-the-job behaviour. This alteration should lead to enhanced individual and organisational performance. The development should encompass at the same time more organisational variables than just culture, structure, strategy, and process. Porras and Robertson (1992) state the change in members’ work behaviour as the most important prerequisite for a meaningful and lasting organisational change. But also the dual focus on individual development and organisational performance as a necessity should not be forgotten.

5.2.1 Importance of individual change

The importance of individual behavioural change was already indicated in the definition and the following statements, but Porras and Robertson (1992) go even further. They negate a significant change over the long run unless the members change their attitudes and let the changed attitudes result in different actions. Over the long run, organisational change cannot occur without individual change, the individual behaviour is therefore an intermediate factor that links change interventions, e.g. changes in formal structures, techniques, and so on, with organisational outcomes. In the view of the linking nature of human behaviour, the most important behaviours are of interest but they differ from organisation and situation, just a few are generalisable across different types of organisations and situations. Open communication, collaboration, taking responsibility, maintaining to a shared vision, and facilitating interventions are illustrative examples for these behaviours and they will lead to an improved organisational output. For a long lasting alteration these behaviours must be changed in the desired direction. But since the desired direction is interpreted by the individuals, a simultaneous change in work settings must be achieved because the individuals draw conclusions from it to form beliefs into which behaviour is appropriate. These work settings will be discussed in the next section.
5.2.2 Influence of work settings

All environmental factors have an influence on the cognition of the employees, and an intra-organisational part of the environment is the work setting. Porras and Robertson (1992) divided the work setting into four categories (see Figure 13). The four categories are called organising arrangements, social factors, physical setting, and technology. All these categories consist of several elements with impact in the behaviour.

![Figure 13: Factors of organisational Work setting (c.f. Porras and Robertson, 1992)](image)

The first category, organising arrangements, consist of formal elements and mechanisms (goals, strategies, structure, administrative policies, administrative systems, reward systems and ownership) and most interventions are aimed at them. If all these elements are consistent with each other and the employees comply with the assumed rationality, they would tend toward the same behaviours. The strongest impact might be given by the reward system and formal structure; for the other elements the result is quite unpredictable because employees might interpret those differently.

In contrast to the formal organisational arrangements, the social factors are more of an informal nature. Here, the patterns and processes of interaction in small or in larger groups are relevant. Specifically, they include culture, management style, interaction process, individual pattern and networks, and individual attributes. This is the human and informal side of the
organisation and is, furthermore, organisation’s intangible part. As such they are difficult to characterise and to change. But a careful treatment consistent with the more formal changes of the organisation increase the likelihood that they can be influenced.

The third category, physical setting, describes objects of the non-technical and non-social part of the environment that influence people’s behave at work. Four elements can be summarised into this category, namely, space configuration, physical ambiance, interior design, and architectural design. The physical setting can do much to block or facilitate effective performing. But it does not induce people to engage in specific behaviours, it can just enhance or reduce the effectiveness. The most significant influence is given by space configuration.

All factors that are directly involved in the input-output transformation are summed up into the fourth category, technology. These factors are tools, equipment and machinery, information technology, job design, work flow design, technical expertise, technical procedures, and technical systems. The more dominant the technology is for the system, the more impact the factors have on individual behaviour. But job design and as a consequence the content of the job have the most powerful impact on individual behaviour – more than any other aspect of the organisation.

All these four factors must be designed to create supportive effects for the on-the-job-behaviour. They are all to be treated separately from each other, but they are inevitably interconnected to each other. This interconnection is highly relevant and a congruence of the factors must be established. This implies also that a change in one factor most likely requires a complementary change in others. If this interdependence is not taken into account, the change is constrained or short-lived. Additionally, these changes send signals to the members; congruent signals highlight the importance of the change and reinforce the effect. As more consistent and congruent these messages are, as more successful the change will occur.

The only element in Figure 13 not treated yet is vision. It includes the long-term factors like core values and organisations enduring purpose and the short-term factors mission and vivid description. The most integration force originates from organisations enduring purpose and the mission. They provide common criteria for decision and help to be congruent with each other even if decisions were made decentralised. They also help to interpret environmental
changes and advise how to respond the decisions. Even for those situations a congruent interpretation is favourable.

The result of the on-the-job behaviour is the organisational outcome. The previously-mentioned dual focus is relevant here. The organisational outcome is not only the tangible output of the production process; it is more precisely the organisational performance and the individual development. All development processes should be addressed to both, organisational and individual level. Just if this is given, a real development or improvement will be achieved. If the development only addresses the organisational performance, the employees will not exploit their complete potential; on the other hand, the organisation will not be interested in the solely development of their employees, it will be also interested in the improvement of the organisational performance.

5.2.3 Application of development interventions

The application of development intervention is guided by two general theories, the change process theory and implementation theory respectively. The first one describes the underlying dynamics of the planned change process, by specifying the variables that can be manipulated. The variables that mediate the effects of manipulated variables on the outcome variable, mediating variable, must be defined as well as the moderating variables describing the causal relationship between manipulate, mediate, and outcome variable. The change process theory is presented in Figure 14.

![Figure 14: Change process model (c.f. Porras and Robertson, 1992)](image)

In the implementation theory, the actual actions are in the centre of interest. They show what has to be done and in which order the changes in the variables are achieved. Here is the complementary aspect of the change, while the change process theory could act more as a strategic framework; the implementation theory is rather the operative element. By using
both, they can bridge from theory to action. A synergetic relationship should be accomplished to integrate the existing knowledge. But the framework must be robust enough to comprehensively specify which variables might be target for diagnosis and action.

With this theoretical framework, a solid base for an application is possible. The change process model shows, how the variables affect each other. With this knowledge, they provide interactions to accomplish the appropriate results. The interventions can be classified according to the target or recipient each most closely affects: the individual aspects, interpersonal aspects, group and inter-group aspects, or overall aspects. The behaviour as the long-term goal becomes obvious through these aspects; in other words, all interventions must have an impact on the individual’s behaviour. The interventions can also be classified in a second dimension, the four categories included in the work setting; organising arrangements, social factors, physical setting, and technology.

5.3 Synthesis

In chapter 5.1, the advantages of the individualist and structuralist approach were presented, but their obvious disadvantages led to the interactive approach, that includes the advantages of both and tries to overcome their disadvantages. But even the interactive process couldn’t solve the combination of the purist forms in an adequate manner, it claimed for a continuous and flexible time-frame without presenting it.

In chapter 5.2, rather a framework than the concrete content were discussed. But an important aspect is contributed: the insignificance of intervention over the long-term when not focussing on the alteration in individual behaviour. Sustainable interventions could therefore only be accomplished by an alteration of individual behaviour.

As a consequence a combined result of both, chapter 5.1 and 5.2, claims for a focus on interventions that are targeted directly to the change of individual behaviour. In terms of the approaches presented in chapter 5.1 the intervention are found in the individualist approach. This is also consistent after due consideration; it needs time to understand why a change in behaviour is necessary. It seems impossible to change human behaviour on the short-term. But this is justifies the existence of structural interventions, even if the predominance in terms of sustainability is approved. Organisations need results not only on the long-term, the most economical environments are highly competitively and results of organisational change must
be obvious immediately. This is most important for the individual member, not only for the organisation. The earlier and the more effective alterations show results, the stronger the members believe in the change concept. And since Slappendel (1996) express the necessity for a continuous transition between individualist and structuralist approach it would be to narrow to exclude structural interventions from a change approach.

As the focus on long-term interventions (section 3 in Figure 15) is already set to interventions that target on individual’s behaviour change and because a continuous transition between an emphasis on individual interventions and an emphasis on structural interventions, the focus on structural interventions is to be found in the short-term perspective (section 1 in Figure 15). The continuous transition will be represented by a hybrid form of individual and structural interventions. Their results will be shown in a mid-term perspective (section 2 in Figure 15).

![Figure 15: Continuous transition from structural to individual approaches](image)

### 5.4 Interventions for an improvement in inter-departmental communication

Before interventions can be classified, it seems necessary to describe the categories of perspectives more precise. The sustainability of the individual interventions on the long-term is a good clue what “long-term” does mean in this content. It does not mean that the interventions should be implemented after a long-term; it means that the results of the
interventions are identifiably for the first time after a long-term and that they are sustainable. In the inversion of that argument, i.e. for short-term interventions, they are identifiable already a short while after the implementation. As the previous discussions proved, the sustainability of short-term interventions is highly restricted. Since a continuous transition between both pure approaches is favourable, the interventions should not only be classified in short-term and long-term interventions. As more precisely the interventions are classified, as easier an evaluation is, but it seems questionable if the exact occurrence of the desired results is predictable. The first results should be notable already after their implementation. The alteration of the individual behaviour must be accomplished at the end of the observation period. All interventions that are a combination of both pure forms should be grouped into one group, because all further categorisations could lead to misunderstanding and misinterpretation of the results.

As a consequence for the implementation, it follows in practice that the manipulable variable must be defined before the implementation of the actions. On these variables the interventions can manipulate. All desired outcome variables must be checked for possible manipulable variables and for consistency and congruency between the outcome variables. If outcome variables are defined and manipulable variables are found, the interventions as part of the implementation theory must be defined. When the interventions to the manipulable variables are found, all interventions should be implemented at the same time. Since the main intention for short-term interventions is to get results immediately it is self-evident to implement them as soon as possible; but even the long-term interventions should be implemented right at the begin of the development, because they already need a lot of time to get the first results, a further delay is not desirably.

In the following sections a sample of intervention is presented. The sample is merely an illustrative example for the interventions that are embraced into the three perspectives and addresses the intra-departmental communication between product design and production, but they can also be used between other and more involved departments; the duration to get first results will increase with more parties involved. The interventions should ensure that an up-to-date knowledge base of all important elements of the processes is available. The actuality should be ensured by establishing a complete knowledge base at the beginning and further updates both incrementally and periodically. Either practitioner or researchers should consider
5.4.1 Short-term

All interventions presented to achieve results after a short-term are structural actions. They are targeting the work setting organisational arrangements and technology, the actual goal to chance the human behaviour, which could be addressed by social factors, will not be treated since a behavioural change could not be accomplished within that short timeframe.

Obliged processes / blank forms

An obliged communication process will ensure that all important aspects of a message are included (e.g. author, involved departments, affected departments, and affected processes). This process consists of a blank form that is to be used for each communicative interaction and also for all changes that occur in the own area of an employee. To ensure that even smaller changes in the routine processes are not fall into oblivion, the obliged process includes the hand-in of the blank form periodically. Hereby, the employees get used to scrutinise his work regularly for changes in any field of their work and eventually find even undiscovered changes in his work. As long as the blank forms are related to alteration in the daily routine, the hand-in of the forms are also elements of distribution of the information. The merely documentation of the results would be meaningless as long they are not distributed. With this regular blank form an incrementally update of the processes is given and the normal intra-departmental communication is documented. But, this is valid for all structural interventions, and as long as the employees do not understand the intention of the new processes, i.e. change their behaviour in the desired direction, they will find ways to dupe the structures. If they are not willing to scrutinise their work they will find some unsubstantial expressions to fill in. The evaluation of the handed-in forms could reduce this effect, but it will still be there. But since behavioural changes should follow, the blank form is, as an obliged and standardised method, an effective way to accomplish quickly an improvement in communication. And in combination with an assumed behavioural alteration, they positive effects will endure.

Naveh (2005) stated that standardisations are possible during the regular production, after market introduction to support the integration. The blank forms as for communication will therefore improve the integration and communication as standardised processes during the regular production.
**Visualised presentation**

The general understanding of the procedures in other departments and especially between production and product design is rather weak. This leads to misunderstandings in communication. A high-priority is most often not on the level with the priority in the other department, but it becomes a problem if the department with the lower priority is not dealing with the task because they did not expect the high-priority but the other department badly want an answer. This scenario is easily to occur if the processes are unknown.

In order to avoid this, the departments compile a presentation of their own department to present the general flow, the contact persons, the requirements and other important features of their processes in a visualised presentation. The visualised presentation only includes the most important aspects and describes neither the details nor the backgrounds; it should just be understandable without any further knowledge. Most often those presentations already exist, but they are most often only presented in the own department. Without presenting the department off-site, the other departments cannot gain any profit of this information. A presentation at a well accessible place within the company or the other department is favourable. When the colleagues from other departments can increase their knowledge about the processes in other departments, they are most likely to support them when it becomes necessary, because they realise that a problem accrues if a task will not solved immediately.

As already mentioned, the presentation should be located at a well accessible place in the organisation. Since most procedures are highly complex, all employees should have easy access to it. That includes top management and blue collar workers. At the beginning the presentation should be installed at each department; in section 5.4.2 an alternative for the installation will be presented.

The visualised presentation could also be used to understand the different jargons and languages between the departments. These kind of techniques were already used to match the different languages between marketing and manufacturing (see Balakrishan, 1995 and Griffin and Hauser, 1992) and since the factors for the marketing-R&D interface are also valid for the R&D-manufacturing interface (Song, 1997) this is transferable to the actual problem.

**Medium for news**

In chapter 2 four different perspectives on communication were introduced (Krone et al., 1987). As a basic component they embraced the channel, which was described as the used medium from sender to receiver. In the case of the intra-departmental communication the medium has the task to distribute the messages between the departments. The possible media
range from written handbooks to a website in the intranet of the organisation. But in the first order, the media must be accessible for all employees without any restrict regarding the usability. If some employees don not have an permanent access to the intranet, this will be occur rather often in the production department at the shop floor level, the intranet will not be a helpful medium. But the extensibility of the intranet websites is extremely useful for incremental up-dates and it seems also possible to provide more and deeper information about all processes and contact persons in the departments. The medium, whether it is an intranet website, a billboard or a written handbook, must embrace the content of the visualised presentation and also deeper information about the background and facts that are assumed as already known to everyone. If not one single medium is practicable, a combination of them is possible. E.g. the billboards are useful in terms of access and visualised presentation, but they are not extensible. The extensions could be undertaken by the intranet or by handbook that are available next to the billboard. But the main specifications of the medium are still the accessibility for all members of the organisation and the actuality.

Facilitator
All media and approaches to distribute information will not be successful, as long as their actuality is not given. A facilitator could fulfil that task in several ways even as a sideline task. He collects the blank forms from all employees in his department or, if the organisation is sizable to employ the facilitator on a full time base, for the entire organisation. If blank forms are missing, he calls form them to ensure the regularity and when all are available, he evaluates them for changes or more precise descriptions. With this information he is able to keep the medium up-to-date. The actualisation of the medium is the second task. The collecting of the blank forms and the actualisation is visualised in Figure 16.
And his knowledge about the processes and the assignments of activities within the department enables him to be the first contact person, when the medium could not answer requests from outside. He could allocate the requests to the specific person in the department due to his knowledge. This knowledge enables him to act as a moderator for disciplinary questions within the department, or together with facilitators from other departments for inter-functional discussions. These specifications seem to require a highly experienced and well-educated person to perform the role of the facilitator. On the other hand, since the aim is the improvement of the communication it is also supposable that the facilitator should always be the office junior. If so, the office junior gets a quick and intensive overview over his own department and he also gets in contact with other department. Both aspects are important for the integration in the new company.

Especially the possibility of getting in contact with other departments seems highly valuable for inter-department relationships. But as mentioned above, one must be very careful with the postulation that the facilitator should always be performed by the office junior, a lot of skills are necessary and some of them are possible not given to youngsters.
Figure 17: Indirect communication through medium or facilitator

In Figure 17, the request of the employee is directed to the medium, he can either find the solution for his problem at the medium or the actual contact person. If he found neither of both he contacts the facilitator of the other department and due to his knowledge about the assignment of activities in his department, he can find the right contact person.

The indirect communication between the sender and the final receiver is not harmful to the interaction. As long as the medium can solve the problem, there is no need to disturb the colleague, just for the case that there is a need for it, the questioner must interrupt his colleague and they can discuss the issue in a direct communication.

A facilitator at the interface between the departments is mentioned in Sun (2001) to distribute the complete task and in Blake and Mouton (1984) to act as a moderator between the groups.

5.4.2 Medium-term

While the interventions for the short-term where focussed on structural settings, the interventions for the medium-term also include some personal and individual aspects. It is now the aim that the employees learn more about the other departments, not only by reading instructions. The short-term interventions were targeting the work settings organisational arrangement and technology; the hybrid form will be highlighted by the addition of social and physical action.

Group presentation

The short-term interventions tried to present the task and flows of the department in a visualised presentation. But since this is only a communication in one direction, there is no chance for an interaction if questions occur. The group presentation goes further beyond the
visualised presentation with giving the possibility to interact. Instead of presenting a chart, the departments guide their colleagues through their facilities and present the all-important information and contact persons at their real work places. All the technologies, skills, machines, and programs are more conceivable when seen in reality. Subsequent to the presentation there is also the chance to interact with the presenting colleagues to discuss further issues and also the chance for a direct response. Beside the advantage of interaction it is obvious that lectured and seen information are better to remember.

**Temporary exchange**

Based on the assumption that a lot of problems in communication between two departments are based on different assumption of the situation, the reason for the different rating must be solved. If employees have different knowledge bases, a different rating is most likely. To reduce these differences the employees learn more about the other department through the visualised or group presentation. But all experienced knowledge is more valuable than by learning. If employees switch into other departments during an internal internship they will increase their insight information tremendously. Each employee has to work yearly in different departments of the company for couple of days; he should have the chance to learn more about the function of his colleagues, not only the up- and downstream. Even if the employee is not very efficient during that, he will gain his efficiency afterwards and the efficiency of the whole system. It might be difficult to achieve the complete and deep understanding of all sequences in the other department, but it would be probably enough to learn the most important ones (e.g. abrasives, time schedules, contact persons, quality requirements). Especially in the actual situation with just two involved parties, it seems practical to implement such a cross-functional internship.

The temporary exchange within one department is an efficient and often used tool to enhance the work contents (Dröge et al., 2000) but even the cross-functional job rotation is mentioned as an effective instrument to improve the inter-functional communication (Paashuis and Boer, 1997).

**Fractional exchange**

In the common relationship between two departments, the departments have a high level of communication within each other but between each a kind of a wall constrains the communication between the departments and filters the information (see Figure 18).
Figure 18: Filter for communication between two departments

This effect results in decreasing communication with increasing distance between sender and receiver (see chapter 2.2.3). In addition to this effect, the organisations group their employees that work together in one department in the same local offices. This may support the intra-departmental communication, but it constrains the inter-departmental communication, because if colleagues neither have professional reasons nor the social possibility to communicate, they are most likely to live without any interaction. Beside of working together in the same spatial location, a common task also enhances the communication between each other. Allen and Henn (2007) denote this as an artefact, because people who work together are also located in the same office, which supports the decreasing level of communication. But they found out that working in the same department adds a constant to the probability of communication between them. Common departmental membership increases the likelihood of communication independent of separation distance. But still, you are more likely to communicate with someone in your department who is also in the neighbouring office than with a department colleague in the next building. This increased probability is pictured in Figure 19; the upper curve shows the increased level of communication for members sharing the same department. The lower curve stands for the probability of communication between members of different departments depending on the distance between them.
With this relationship the spatial location of employees can also improve the communication between two departments. If intra-departmental communication is still on high level it does no matter whether the employees work in the same office or not and the inter-departmental communication increases because or the spatial closeness of the employees, the organisation can group people of different departments together in one office to reduce the effects of spatial separation. But since the even the intra-departmental communication will decrease (the intra-departmental communication will always remain on a higher level, see Figure 19), it is a trade-off between the increase of inter-departmental communication and the decrease of intra-departmental communication. This trade-off has no absolute optimum; the effects depend on the moved proportion of employees and the given architectural setting. The results are shown in Figure 20 and the organisation can chose on the corresponding curve to their architectural setting, either the wanted proportion moved, the proportional decrease of intradepartmental communication or the wanted proportional increase of intra-departmental communication.
The inter-departmental communication can be improved by a fractional exchange of employees to the office of another department, the downside effect is the decrease of intra-departmental communication, but because the overall level of communication is higher than before, it might be useful to move a small fraction of the department into another office. This is highly effective, if the moved fraction is an autonomous group within the own department. The increasing overall communication level becomes obvious if comparing the communication flows in Figure 18 and Figure 21. In addition to the filtered ways, the crossed ways are unfiltered and improve the overall communication level.

Except of the extended description of a fractional exchange in Allen and Henn (2007) the same intervention was already discussed by Adler (1995).
Workspace design

Beside the fact where people have their workplace, an architectural aspect can influence the communication behaviour at work (Allen and Henn, 2007). Since the probability that people spend the whole day at their individual workplace is rather low, the design of the complete building is to be considered. Local plants, laboratories, coffee places, cafeterias, conference rooms are also rather often used; these centres of gravity are the true determinants of communication likelihood because people could also meet there. And it is possible to shift people’s centre of gravity without changing their office locations, the centres of different departments must be shared with other departments. Instead of providing a conference room and a coffee place for each department, common locations are reasons for employees to travel to them and to leave their own departmental offices. And travelling around, will increase the possibility that people who rarely communicate run into each other and interact. It is therefore an asset to create functional inconveniences for the employees in order to force them to travel to their centres of gravity. Beside the possibility of communication, the common places can be used to present the visualised presentations if they are presented on a board. A warm and cosy coffee place is not only a place where you enjoy your coffee break, if it is shared with other departments; it enables the employees to get in touch with each other both, at the coffee place and on the way to it. People might spend more time at the common places as they did before, but if the organisation decides to improve their communication, the shared spaces are a way to support communication; and the consistence in the actions is important. Further reconstructions of the architecture are also recommended. It is questionable if all managers do need their own office or if all offices must have walls or if it is possible to substitute the walls by windows.

5.4.3 Long-term

The medium-term interventions build the bridge from rather structural actions to more individual action. The long-term interactions were focussed on interventions that influence directly the social behaviour. They should convince people to change their behaviour in the desired direction and not to hoodwink the structures.

Permanent exchange

Some employees have been working for their actual department since a couple of years, so they do have a lot of tacit knowledge in their field and they are most likely to perform their daily routines in a professional and efficient way. But since they have routine in most of their
tasks, they do not have to think about them. They are aware of solutions for most of the common problems and therefore it is not necessary for them to think about implications of their work. Also, they are unlikely to think about possible improvements because they accept the situations as given and not questionable. This leads to an efficient but not effective method. It is also possible that they lose their intrinsic motivation in their work. There is no stimulus for them anymore. Over the years they could have lost their affection to their job and a new job could provide a new stimulus for intrinsic motivation. After a temporal exchange or internal internship at another department the employees should be able to decide if a permanent change is of interest for them. If that is the case, an exchange to another department with new tasks will lead to an increasing effectiveness. It is now in the interest of both, the employee and the organisation, to develop a way to a possible exchange. Otherwise the employee would quit internally. But the employee must have the qualification to work at the other department; even if this is given it probably takes some time to change completely.

It has been shown that the effective communication link back to the old divisions will last for approximately one year of exchange. The improved communication after the exchange is determined by the change rate and the turnover of personnel. For stable activities and a low turnover, the positive effects on the communication will be effective over a longer time period (Allen, 1977).

**Educational training**

All gathered information is depending on time: after some time the information is no longer actual and therefore an update of information is necessary. This updated information can either be achieved through the presentation of every department, or by an educational training. While the group presentation most likely would be more practical, an educational training could fill this gap by providing the theoretical backgrounds. And for long-lasting changes in human behaviour the understanding for the processes requests the background theories. If only the applications are known without the theoretical backgrounds, all routine tasks will work without any problems, but if deviations from the regular procedure occur, one will not be able to handle this without the theoretical backgrounds.

The training should be held by the same trainer who is implementing the program. Depending on the implication on other departments and on the complexity or radicalism of the change, the training should be held immediately after the implementation or just after the first experiences. And even if there are no modifications, a refreshment of the work flows is helpful after a while.
That an educational training as an important element for employees especially in cross-functional settings is highlighted by Dröge et al. (2000), Paashuis and Boer (1997) and Priest et al. (1994).

**Reward system**

The implementation of a reward system focussed on the measurements all over the organisation is important. The overall maximum is higher than the sum of all sub-maxima measurements and different goals for different departments will create artificial barriers between them. The implementation of a super-oriented goal for all departments will overcome this barrier and create a need for communication between the departments (Ginn and Rubenstein, 1986).

The reward system could also include a continuous improvement process with a special focus on communication to enhance the communication between the departmental interfaces. For such an improvement process it is necessary for the employees to have open eyes for all occurring problems and think about all possibilities for improvements.

But this intervention requires the mindfulness of the members and therefore a change in the behaviour. Although the reward system works as an external factor on motivation; it seems to act also as a supporting factor to change the behaviour.

### 5.5 Conclusion

The presented framework emphasises the importance of both structural and individual interventions when implementing new communicative setups between two departments. But instead of dividing both approaches in to two stages, a continuous transition between them is favourable. By doing that the timing is important, since the structural actions will lead rapidly to results, an implementation of those intervention right at the beginning is useful. However, there is no reason to wait with individual actions; they need more time to show results because they are focussed on the change of individual behaviour. A delay of the implementation will lead to further delays of the results and since only the change of individual behaviour will lead to a sustainable change, it is important to start early. The structural changes will slack in their strength after a while as long as the employees didn’t changed their behaviour.

The supposed interventions exposed the relevance of structural interventions and individual interventions as first or latest results, respectively. Between these pure forms of interventions
a hybrid form unifies both forms; a further classification is not helpful because the measurement of these hybrid results will vary for different settings. The interventions are merely an origin for further deliberations to get some hints for contents of the classifications.
6 Ascertain the attitude towards several interventions for an improved communication

In the first part of the questionnaire, it was asked for the actual state of communication patterns within the organisation. This was performed to analyse the communication pattern and relationships between the variables within the organisation. Possible areas for improvements were disclosed.

The framework presented in chapter 5 explained some possible interventions for an improved communication interface between two different departments, more specifically between R&D and production. But more important, chapter 5 presented a phase model for a continuous transition from structural interventions to individual interventions.

The second part of the questionnaire was performed to ask for the attitude and opinion of the employees toward several interventions. The same group of employees were asked by email to complete the second part, and again a web form was used to collect the data of the questionnaire. In this part of the questionnaire the style of questions were almost exclusively check-box questions, either with a five point Lickert-scale or with a standard Kano-questionnaire with five points on a functional scale and five points an a dysfunctional scale regarding to each element. The complete second part of the questionnaire is shown in Appendix E.

6.1 Intention of the second part of the questionnaire

If employees reject their daily routines they are most likely not able to achieve their full potential in their professional field. And a rejection is to be expected if the attitude towards it is negative. The questionnaire to ascertain the attitudes, therefore, asked for opinions and feelings of the employees towards several interventions of the previous-described model. It also asked for the reasons, which are from the view of the employees, responsible for the disturbance of the communication. These questions will allow drawing conclusions, on which field interventions are wanted and desired. The sole implementation, without any educational training will not lead to positive results over the long-term; a change in behaviour is always indispensable. If fields that require additional support are known in advance, they could be included in the training and the implementation process could be facilitated.
6.2 Structure of the second part of the questionnaire

At the beginning of the second part of the questionnaire, the employees were asked to specify the areas of their related problems and the frequency of their occurrence. For that reason the questionnaire proposed a selection of reasonable and frequently noticed problems. The person asked was requested to state his/her corresponding frequency on a five point Lickert-scale (see Figure 22). A more detailed view on the field of the problem area was expected to gather from these questions.

Since the main intention of the second part of the questionnaire is to gather information about the attitude of the employees toward the interventions presented, a larger fraction of the second part was dedicated to those questions. Even if it is difficult to ask for a future condition, the Kano-styled questionnaire seems to be practical to gather personal information about the feelings and attitudes of persons. It asks not only for the functional purpose of the intervention. This might be difficult to ask, because since the interventions should improve the actual condition of the communication, the most intervention would rather get positive ratings. With an additional dysfunctional question to the same intervention the person must also give information about his/her feelings for the case the intervention is not implemented. By using this setup, a Kano-questionnaire is extremely helpful if the future condition is unknown to the asked person. A Kano-question with its functional and dysfunctional types is visualised in Figure 23.
Figure 23: Example for Kano styled question

While it was interesting to know on which fields problems regarding the communication process occur, it will also be interesting to know which factors hinder the communication between the departments or within the department. For this purpose a five point Lickert-scale was used.

The last fraction of the second part treated an internal internship as a possible intervention to improve the communication process. Chapter 2 and 3 suggest the importance of that intervention and since the concept of it is well known, it is possible to ask for opinions regarding that intervention. Since it is widely known it is purposeful to ask specially that intervention more extensively than others.

The lack of the level of awareness is also the reason why not all of the interventions are included into the questionnaire. The more complex and unknown the concepts are, as more difficult it is to explain the concepts within the limited space of the questionnaire. And an unknown or not understood concept would not lead to a fair rating of the intervention. Nevertheless, it seems possible to draw conclusions. If the acceptance towards changes in general is high, it is liable to expect a higher acceptance in reality than for those questions with a low rating.

Last but not least the employee got the chance to add his/her own opinion and suggestion in an open question to get a real chance to interact with his/her experiences from the daily work life.
6.3 Results of the second part of the questionnaire

6.3.1 Occurring problems

When asked for the problems that occur during communication (see Appendix F), the answers showed an average value of 2.68 on the five Point Lickert-scale. That implies that the problems occur rarer than sometimes. Hence, the problems seem not to be relevant. The highest deviation from that average value was obtained for incomplete information (+0.74) and language problems (-0.68). But since the absolute value for incomplete information is 3.42, which is barely above 3, the value implying a problem occurs sometimes, a crucial problem seems not to be existent. The absolute value for language problems is exact 2, since that implies rather seldom, a problem seems not to be evident.

6.3.2 Hinders that affect communication

The same results were obtained, which are no recognised problems and no outliers, when analysing hinders standing responsible for the problems (see Appendix F). The average value was measured to 2.71, with the strongest deviation of +0.42 for the fact that the own department does not know enough about the processes in other department. But again the absolute value, 3.14, was just above the value indicating that a problem occurs sometimes and, hence, showed no relevance.

6.3.3 Attitudes toward several interventions

With the Kano-styled questions (see Figure 23) the employees were asked to their opinions about the necessity of specific interventions (see Appendix G). The functional and dysfunctional parts of each question are a probate means to get information about the feelings and opinions toward the interventions. Firstly, the questions were classified into the six categories attractive, one-dimensional, indifferent, reverse, must-be, and questionable, by using the Kano-matrix. In the second step, the categories were summed up to the absolute value and the percentage. The positive BETTER features “attractive” and “one-dimensional” were added, as well as the WORSE features, “must-be” and “reverse”. The values for each question are plotted into Figure 24. The more the elements are located in the upper left corner, the more attractive they are. Only the result of the fourth Kano-question is located in the upper left corner, which implies that the employees identified interventions supporting the better understanding between the departments as attractive and useful for improvement. This question exceeds also the conditions for significance. The category strength, the difference
between the highest percentage and the next highest, is with 28% higher than the limit value 7%. The total strength of the question, the sum of the values indicating “attractive”, “must-be”, and “one-dimensional”, reaches exactly the limit value 70%, see Appendix G for further values. All other five asked interventions seem not to be attractive to the employees. But since the other values are located on the diagonal to “must-be”, these elements, namely formal meetings, informal meetings, closer located offices, faster responses, and standardised way of communication, must also be included into the implemented interventions.

![Figure 24: Kano attributes for the interventions.](image)

### 6.3.4 Attitudes toward an internal-internship

When asked about the influence of an internal internship, the answers ranged from not-at-all to absolutely. An average of 3.5 was obtained, but almost the half of the people that were asked, stated that the internal-internship is absolutely necessary. Although, they identified the internal-internship as an adequate way to improve the communication, these employees were only poised to join an internship. When further asked, if they would be ready to participate in a fractional exchange or in a permanent exchange, they were only ready under certain conditions. The average values of 2 (rather not) for the permanent exchange and of 3 (under certain conditions) for the fractional exchange were obtained.
6.4 Discussion of the second part of the questionnaire

The problems and weaknesses discussed for the first part of the questionnaire in chapter 4.4 are also valid for the second part. It is difficult and not recommendable to draw strong conclusions of these results. The results should be rather used as an origin for further researches with more employees asked. Some weaknesses of the questionnaire should be remodelled to get more valuable answers.

6.4.1 Discussion of occurring problems

None of the asked problems occur in a crucial frequency. Either the employees do not have these problems while their communication or they haven’t recognised these problems yet. If the employees haven’t recognised the problems, their attention towards their daily routines is astonishingly low. Since the problems are highly relevant in other studies, see Song et al. (1997) for the problem of different jargons at different departments, this fact must be investigated in further studies and by educational training that highlight the importance of awareness. But the missing relevance of the problems can also be caused by the verbalisation of the question, if so; more precise questions should be included in further questionnaires.

6.4.2 Discussion of hinders that affect communication

Also for the asked hinders that affect communication no relevance was evident. Again, this could be caused by the verbalisation of the questions or by the missing attention of the employees. Even for these questions it is interesting to know which reason is responsible for the lack of relevance.

6.4.3 Discussion of the attitudes toward several interventions

The results of the Kano-styled questions in chapter 6.3.3 indicating the relevance of a better understanding between the departments for the processes in the different departments, showed, that the cognition for improvements is given; although other interventions, for example faster responses, were not attractive to the employees. The organisation should implement such interventions to support the understanding for the other departments. The visualised presentation and the presentation of the department in the own facilities are such interventions. When gathering more details about the procedures of other departments, employees would not only be able to understand their needs and requirements in a better way, they would be able to recognise occurring problems earlier.
6.4.4 Discussion of the attitudes toward an internal-internship

The internal-internship would be a more sustainable intervention to gain this understanding. Even if the average value was barely above 3, almost half of the employees recognised the internal-internship as an absolute necessity. The fact that they are ready to participate in an intern-internship-program shows that they would like to do something to improve the communication. But they are not ready to leave their old departmental tasks and colleagues yet. They are still intrinsic motivated by their tasks and see a good connection to their colleagues, therefore they are not willing to leave both, tasks and colleagues, for longer than an internship. The retentiveness against the fractional exchange shows that they are in good and valuable contact to their departmental colleagues, and they would only be poised to miss them under certain conditions. Eventually, the participation of the most valuable colleagues in those programs is a condition under which they would be more willing. The even weaker acceptance of the permanent exchange shows that the employees are still intrinsic motivated by their departmental tasks. And this is of course a good result in regard of the effectiveness and motivation at work.
7 Summary and discussion

The need for harmonic flows within an organisation is obvious and will get more and more important for the success in the future. Of course it is still the product that will be crucial for the success on the market and therefore the coordination between manufacturing, the relevant department for production, and design, the relevant department for the development of the product, is crucial for the success on the market. The different requirements and thought worlds complicate the coordination of organisation. Recently occurred problems showed that the communication between them is insufficient and leads to major failures in production.

The present thesis discusses the requirements of a sufficient communication between different departments and proves that results already known for different departments are also valid for the design-manufacturing interface. With the existence of this validity was it also possible to draw conclusions for the application of communicative interventions.

For the implementation of a new model it was still necessary to gain more information about an implementation process. Since employees are involved in the coordination and communication between the two departments, it seems important to include the human behaviour into the model. This might not be necessary for the implementation of a new technology, but for implementations in context with human beings.

Two purist methods of interventions being focussed either on structural actions or on the change of human behaviour were crystallized. The first method was focussed on changes in the organisational and administrative settings of the working environment. The results of these interventions can be achieved rapidly after the implementation. But since human beings tend to find ways to bypass structural settings, if they do not understand their complete meaning, the change of human behaviour is indispensable for organisational change. But changing human behaviour will last longer and requisites more and repetitively actions. Of course, only these changes will lead to a sustainable change of the entire process.

Although only the change of human behaviour leads to sustainable alteration, it is also important to include structural interventions into the change process. They will rapidly lead to results, which is important for both organisations and people. While the organisations need results as soon as possible to compete on the market, the employees need the results to gain
believe in the interventions. That implies that both purist methods must be included and the timing between the methods is not restricted by the time needed for implementation but by the time after which first results are visible. The structuralist interventions will lead earlier to results than the individualist approaches, but they should be implemented both at the beginning of the change process, to avoid further delays of the results. A classification is still necessary to not expect the results at the wrong moment. It would be dangerous for the whole process if results of individual changes would be expected too early, as employees loose their faith and stop supporting the process. A continuous transition between the purist methods with hybrid interventions could lighten the implementation.

To get some ideas about possible interventions, illustrative examples for structural, hybrid, and individual interventions were presented. This listing is neither complete nor valid for universal organisations. It is rather a first point of orientation for further considerations. For each environment or work setting other interventions will be favourable. But a solid theoretical base is provided by the listed interventions in connection with the implementation process.

This framework was tested by the employees of the HELIX partners for their statement to the interventions. Since the implementations were not implemented yet, questioning was merely on a hypothesised base. Also, due to the unexpected low response rate further conclusions are difficult to draw. But with a further, full scale questionnaire the results will be more significant. At the actual moment the results of the questionnaire can be named to:

- The older the people get, the more they use spontaneous meetings for the communication between design and manufacturing
- With increasing complexity of the message the frequency of emails used for intra-departmental communication decreases
- With increasing complexity of the message the frequency of communication via intranet for the communication between design and manufacturing increases
- The most attractive element for improvements is focussed on the improvement of understanding the requirements and processes in the other departments.
- The elements formal meetings, informal meetings, closer located offices, faster responses, and standardised way of communication are rather must-be features for the interventions.
• Questions regarding problems and hinders should be asked in check-boxes and should be selected after a first survey.

In further studies, performed after the implementation, the interventions should be validated regarding the moment of their results, the strengths of the results and the acceptance of the interventions by the employees. The investigation of the moment of the result will help to find a more precise classification, which will lead to a smoother sequence of the entire implementation process.
References


Appendix A – First part of the questionnaire

Demografi

1) Hur gammal är du?

2) Hur många år har du jobbat för ditt företag?

3) Vilken utbildning har du?

4) Hur många år har du jobbat i yrket, i vilket du gjorde din utbildning?

Generellt

1) Vad lägger du i begreppet "kommunikation"?

2) Arbetar du i ett team med medlemmar från olika avdelningar?

Om du arbetar i ett team med medlemmar från olika avdelningar, vilka avdelningar är det (använd fullständigt namn)?
3) Vilken roll har din avdelning i företaget?
Kommunikation inom din egen avdelning

1) Vad är din egen avdelning?  

2) Vad är det viktigaste målet inom din avdelning?  

3) Hur kan man mäta målen?  

4) Är det möjligt att uppnå målen?  

5) Hur många gånger per dag kommunicerar du med dina kollegor?  

6) Hur länge kommunicerar ni med varandra per gång?  

7) Om vilka ämnen kommunicerar ni?  

8) Hur komplicerad är ämnen?  

- [ ] Enkelt  
- [ ] Medel  
- [ ] Mycket komplex  

9) Finns det ett standardiserade sätt för kommunikation?  

- [ ] Ja  
- [ ] Nej  

Om det finns ett standardiserat sätt för kommunikation, var snäll och beskriv det! T.ex. formella diskussioner, eskalerings strategi, kända kontaktpersoner etc.
10) Vilka informations kanaler nyttjar du?

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11) Varför kommuniserar ni med varandra?

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Kommunikation inom hela företaget

1) Vad är det viktigaste målet inom företaget? ________________________________
2) Hur kan man mäta målen? ________________________________
3) Är det möjligt att uppnå målen? ________________________________

4) Med vilka andra avdelningar kommunicerar du? ________________________________
5) Med vilka andra avdelningar kommunicerar du mest? ________________________________

6) Hur många gånger per dag kommunicerar du med dessa kollegor? ____________
7) Hur länge kommunicerar ni med varandra per gång? ____________
8) Om vilka ämnen kommunicerar ni? ________________________________
9) Hur komplicerad är ämnen?
   - O enkelt
   - O medel
   - O mycket komplex
   - O O

10) Finns det ett standardiserat sätt för kommunikation i hela företaget?
   - O Ja
   - O Nej
   Om det finns ett standardiserat sätt för kommunikation, var snäll och beskriv det!
   t.ex. formella diskussioner, eskalerings strategi, kända kontaktpersoner etc.
11) Vilka informations kanaler nyttjar du?

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12) Varför kommunicerar ni med varandra?

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### Appendix B – Correlation with the age

#### Correlations between age of the employee and the channels used

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<td>0.682759434</td>
<td>68.28%</td>
</tr>
<tr>
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<td>0.110897747</td>
<td>0.11135575</td>
<td>0.11135575</td>
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<td>0.588119974</td>
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</tr>
<tr>
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<td>0.48467771</td>
<td>0.48467771</td>
<td>0.869355419</td>
<td>0.833816505</td>
<td>83.38%</td>
</tr>
<tr>
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<td>-0.59818841</td>
<td>-0.690321363</td>
<td>0.690321363</td>
<td>1.380647225</td>
<td>0.91630558</td>
<td>91.63%</td>
</tr>
<tr>
<td>between</td>
<td>0.012296469</td>
<td>0.012296469</td>
<td>0.012296469</td>
<td>0.024592938</td>
<td>0.509810174</td>
<td>50.98%</td>
</tr>
<tr>
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<td>0.141049574</td>
<td>0.145119974</td>
<td>0.145119974</td>
<td>0.290239588</td>
<td>0.61413524</td>
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</tr>
<tr>
<td>formal</td>
<td>-0.233359205</td>
<td>-0.23771458</td>
<td>0.23771458</td>
<td>0.475429135</td>
<td>0.682759434</td>
<td>68.28%</td>
</tr>
<tr>
<td>spontaneous</td>
<td>0.877100361</td>
<td>1.363057714</td>
<td>1.363057714</td>
<td>2.726115428</td>
<td>0.996795771</td>
<td>99.68%</td>
</tr>
<tr>
<td>telephone</td>
<td>-0.171387427</td>
<td>-0.173095728</td>
<td>0.173095728</td>
<td>0.346191457</td>
<td>0.835400583</td>
<td>63.54%</td>
</tr>
<tr>
<td>email</td>
<td>0.56682083</td>
<td>0.643063851</td>
<td>0.643063851</td>
<td>1.286127703</td>
<td>0.900080751</td>
<td>90.08%</td>
</tr>
<tr>
<td>face2face</td>
<td>-0.278843647</td>
<td>-0.28642779</td>
<td>0.28642779</td>
<td>0.572855579</td>
<td>0.716628758</td>
<td>71.66%</td>
</tr>
</tbody>
</table>
### Appendix C – Correlation with the complexity of the message

<table>
<thead>
<tr>
<th>Channel</th>
<th>peererson</th>
<th>Fisher</th>
<th>normieren</th>
<th>Standardisieren</th>
<th>STANDNORMVERT</th>
<th>p0 verwerfen zu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Board</td>
<td>0.683985568</td>
<td>0.858655371</td>
<td>0.835655371</td>
<td>1.673130741</td>
<td>0.95284922</td>
<td>95.28%</td>
</tr>
<tr>
<td>within own department</td>
<td>0.57049487</td>
<td>0.648258183</td>
<td>0.648258183</td>
<td>1.296512366</td>
<td>0.902600489</td>
<td>90.26%</td>
</tr>
<tr>
<td>spontaneous formell</td>
<td>0.20519567</td>
<td>0.208150628</td>
<td>0.208150628</td>
<td>0.416301257</td>
<td>0.661405213</td>
<td>66.14%</td>
</tr>
<tr>
<td>telephone</td>
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<td>-0.29527429</td>
<td>0.29527429</td>
<td>0.59058579</td>
<td>0.722588536</td>
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</tr>
<tr>
<td>email</td>
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<td>-1.611494105</td>
<td>1.611494105</td>
<td>3.223988209</td>
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</tr>
<tr>
<td>face2face</td>
<td>-0.805978979</td>
<td>-0.704120928</td>
<td>0.704120928</td>
<td>1.408241851</td>
<td>0.920470266</td>
<td>92.05%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Channel</th>
<th>peererson</th>
<th>Fisher</th>
<th>normieren</th>
<th>Standardisieren</th>
<th>STANDNORMVERT</th>
<th>p0 verwerfen zu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Board</td>
<td>-0.596039561</td>
<td>-0.886981807</td>
<td>0.886981807</td>
<td>1.373963814</td>
<td>0.91527311</td>
<td>91.53%</td>
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<tr>
<td>within the entire organisation</td>
<td>0.283157895</td>
<td>0.28949825</td>
<td>0.28949825</td>
<td>0.538998501</td>
<td>0.705055365</td>
<td>70.51%</td>
</tr>
<tr>
<td>formal</td>
<td>0.584280094</td>
<td>0.639102424</td>
<td>0.639102424</td>
<td>1.278204848</td>
<td>0.899411396</td>
<td>89.94%</td>
</tr>
<tr>
<td>spontaneous</td>
<td>0.280975743</td>
<td>0.288741313</td>
<td>0.288741313</td>
<td>0.577482272</td>
<td>0.718193145</td>
<td>71.82%</td>
</tr>
<tr>
<td>telephone</td>
<td>-0.250386968</td>
<td>-0.255825332</td>
<td>0.255825332</td>
<td>0.511650664</td>
<td>0.6955224</td>
<td>69.56%</td>
</tr>
<tr>
<td>email</td>
<td>0.132453238</td>
<td>0.133236073</td>
<td>0.133236073</td>
<td>0.266472146</td>
<td>0.60506196</td>
<td>60.51%</td>
</tr>
<tr>
<td>face2face</td>
<td>0.374634325</td>
<td>0.393803235</td>
<td>0.393803235</td>
<td>0.78760647</td>
<td>0.784536355</td>
<td>78.45%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Channel</th>
<th>peererson</th>
<th>Fisher</th>
<th>normieren</th>
<th>Standardisieren</th>
<th>STANDNORMVERT</th>
<th>p0 verwerfen zu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Board</td>
<td>0.341565025</td>
<td>0.35563186</td>
<td>0.35563186</td>
<td>0.711726373</td>
<td>0.761682883</td>
<td>76.17%</td>
</tr>
<tr>
<td>between design and manufacturing</td>
<td>0.85898443</td>
<td>1.289457851</td>
<td>1.289457851</td>
<td>2.57915303</td>
<td>0.995044446</td>
<td>99.50%</td>
</tr>
<tr>
<td>formal</td>
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<td>0.288741313</td>
<td>0.288741313</td>
<td>0.577482272</td>
<td>0.718193145</td>
<td>71.82%</td>
</tr>
<tr>
<td>spontaneous</td>
<td>0.250386968</td>
<td>0.255825332</td>
<td>0.255825332</td>
<td>0.511650664</td>
<td>0.6955224</td>
<td>69.56%</td>
</tr>
<tr>
<td>telephone</td>
<td>-0.250386968</td>
<td>-0.255825332</td>
<td>0.255825332</td>
<td>0.511650664</td>
<td>0.6955224</td>
<td>69.56%</td>
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<tr>
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<td>0.639102424</td>
<td>0.639102424</td>
<td>1.278204848</td>
<td>0.899411396</td>
<td>89.94%</td>
</tr>
<tr>
<td>face2face</td>
<td>0.20519567</td>
<td>0.208150628</td>
<td>0.208150628</td>
<td>0.416301257</td>
<td>0.661405213</td>
<td>66.14%</td>
</tr>
</tbody>
</table>
Correlations between duration of the employee in the organisation and the channels used

<table>
<thead>
<tr>
<th>Channels</th>
<th>Board</th>
<th>Pearson</th>
<th>Fisher</th>
<th>normieren</th>
<th>Standardisieren</th>
<th>STANDNORMALISIEREN</th>
<th>verwerfen zu</th>
</tr>
</thead>
<tbody>
<tr>
<td>within own</td>
<td>Intranet</td>
<td>-0.279824654</td>
<td>-0.28749182</td>
<td>-0.295829943</td>
<td>-0.591659886</td>
<td>0.27703918</td>
<td>27.70%</td>
</tr>
<tr>
<td></td>
<td>formal</td>
<td>0.082352541</td>
<td>0.082539472</td>
<td>0.082727683</td>
<td>0.165455365</td>
<td>0.5657021</td>
<td>56.57%</td>
</tr>
<tr>
<td></td>
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<td>0.175703852</td>
<td>0.177542014</td>
<td>0.179447876</td>
<td>0.358857535</td>
<td>0.64016346</td>
<td>64.02%</td>
</tr>
<tr>
<td></td>
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<td>0.327647238</td>
<td>0.340190249</td>
<td>0.354307661</td>
<td>0.708615322</td>
<td>0.76071839</td>
<td>76.07%</td>
</tr>
<tr>
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<td>0.307589941</td>
<td>0.336093531</td>
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<tr>
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<td>0.256857732</td>
<td>0.229336457</td>
<td>0.458672915</td>
<td>0.67676547</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>-0.404241448</td>
<td>-0.428708535</td>
<td>0.700800747</td>
<td>1.401601495</td>
<td>0.91948286</td>
<td>91.95%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Channels</th>
<th>Board</th>
<th>Pearson</th>
<th>Fisher</th>
<th>normieren</th>
<th>Standardisieren</th>
<th>STANDNORMALISIEREN</th>
<th>verwerfen zu</th>
</tr>
</thead>
<tbody>
<tr>
<td>within the</td>
<td>Intranet</td>
<td>-0.177764622</td>
<td>-0.179673415</td>
<td>0.210467019</td>
<td>0.420934038</td>
<td>0.66309838</td>
<td>66.31%</td>
</tr>
<tr>
<td>entire</td>
<td>formal</td>
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<td>-0.107529765</td>
<td>0.28984128</td>
<td>0.579682561</td>
<td>0.71893565</td>
<td>71.89%</td>
</tr>
<tr>
<td>organisation</td>
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<td>-0.920708977</td>
<td>0.237714568</td>
<td>0.475429135</td>
<td>0.68275943</td>
<td>68.28%</td>
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<tr>
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<td>0.11135575</td>
<td>0.222711499</td>
<td>0.58811997</td>
<td>58.81%</td>
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<td>email</td>
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<td>0.450318954</td>
<td>0.48467771</td>
<td>0.969355419</td>
<td>0.83381606</td>
<td>83.38%</td>
</tr>
<tr>
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<td>-1.449219373</td>
<td>0.690321363</td>
<td>1.380642725</td>
<td>0.91630558</td>
<td>91.63%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Channels</th>
<th>Board</th>
<th>Pearson</th>
<th>Fisher</th>
<th>normieren</th>
<th>Standardisieren</th>
<th>STANDNORMALISIEREN</th>
<th>verwerfen zu</th>
</tr>
</thead>
<tbody>
<tr>
<td>between</td>
<td>Intranet</td>
<td>-0.193695291</td>
<td>-0.196173669</td>
<td>0.012296469</td>
<td>0.024592938</td>
<td>0.50981017</td>
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</tr>
<tr>
<td>design and</td>
<td>formal</td>
<td>-0.72623264</td>
<td>-0.920708977</td>
<td>0.237714568</td>
<td>0.475429135</td>
<td>0.68275943</td>
<td>68.28%</td>
</tr>
<tr>
<td>manufacturing</td>
<td>spontaneous</td>
<td>0.677609193</td>
<td>0.624680233</td>
<td>1.363057714</td>
<td>2.726115428</td>
<td>0.99679577</td>
<td>99.68%</td>
</tr>
<tr>
<td></td>
<td>telephone</td>
<td>0.285866379</td>
<td>0.294058952</td>
<td>0.173095728</td>
<td>0.346191457</td>
<td>0.63540058</td>
<td>63.54%</td>
</tr>
<tr>
<td></td>
<td>email</td>
<td>0.244033128</td>
<td>0.249058174</td>
<td>0.643063851</td>
<td>1.286127703</td>
<td>0.90080075</td>
<td>90.08%</td>
</tr>
<tr>
<td>face2face</td>
<td></td>
<td>-0.644247459</td>
<td>-0.765401353</td>
<td>0.28642779</td>
<td>0.572855579</td>
<td>0.71662876</td>
<td>71.66%</td>
</tr>
</tbody>
</table>
Förbättringar för kommunikation mellan forsknings – och utvecklingsarbete och produktion

1) Vilka sorter av problemen finns det med kommunikation?

<table>
<thead>
<tr>
<th>Kommunikationen är opersonlig</th>
<th>Aldrig</th>
<th>Ibland</th>
<th>Aldrig</th>
<th>Ibland</th>
<th>Alltid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mina problem är ointressanta för de andra</td>
<td>Aldrig</td>
<td>Ibland</td>
<td>Aldrig</td>
<td>Ibland</td>
<td>Alltid</td>
</tr>
<tr>
<td>Andras problem är ointressanta för mig</td>
<td>Aldrig</td>
<td>Ibland</td>
<td>Aldrig</td>
<td>Ibland</td>
<td>Alltid</td>
</tr>
<tr>
<td>Okänt språk/uttryck</td>
<td>Aldrig</td>
<td>Ibland</td>
<td>Aldrig</td>
<td>Ibland</td>
<td>Alltid</td>
</tr>
<tr>
<td>Ofullständiga informationer</td>
<td>Aldrig</td>
<td>Ibland</td>
<td>Aldrig</td>
<td>Ibland</td>
<td>Alltid</td>
</tr>
<tr>
<td>Jag/Vi erkänner problemen till de andra för sent</td>
<td>Aldrig</td>
<td>Ibland</td>
<td>Aldrig</td>
<td>Ibland</td>
<td>Alltid</td>
</tr>
</tbody>
</table>

Andra:

2) Förstår du frågor (du har inte problem med uttryckssätt) från andra avdelningar?

| Aldrig | Ibland | Aldrig | Ibland | Alltid |

3) Är frågorna/problemen beskrivna tillräckligt noga?

| Aldrig | Ibland | Aldrig | Ibland | Alltid |
4) Med vilka aktiviteter kan man förbättra kommunikation mellan forsknings- och utvecklingsarbete och produktion? (Om det finns redan en av dessa aktiviteter, var snäll och markera denna!)

<table>
<thead>
<tr>
<th>Om det finns regelbundna möten (t.ex. var annan vecka), vore det bra.</th>
<th>Jag tycker om det.</th>
<th>○</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Det är en måste.</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>Jag är neutral.</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>Jag kan leva med det.</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>Jag tycker inte om det.</td>
<td>○</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Om det inte finns regelbundna möten (t.ex. var annan vecka), vore det bra.</th>
<th>Jag tycker om det.</th>
<th>○</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Det är en måste.</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>Jag är neutral.</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>Jag kan leva med det.</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>Jag tycker inte om det.</td>
<td>○</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Det skulle vara bra om det fanns informella möten (t.ex. gemensam lunch)</th>
<th>Jag tycker om det.</th>
<th>○</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Det är en måste.</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>Jag är neutral.</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>Jag kan leva med det.</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>Jag tycker inte om det.</td>
<td>○</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Det skulle inte vara bra om det fanns informella möten (t.ex. gemensam lunch)</th>
<th>Jag tycker om det.</th>
<th>○</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Det är en måste.</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>Jag är neutral.</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>Jag kan leva med det.</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>Jag tycker inte om det.</td>
<td>○</td>
</tr>
<tr>
<td>Det skulle vara bra om kontor/verkstad var placerade närmare varandra.</td>
<td>Jag tycker om det.</td>
<td>○</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Det är en måste.</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Jag är neutral.</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Jag kan leva med det.</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Jag tycker inte om det.</td>
<td>○</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Det skulle vara bra om jag fick bättre förståelse för andra avdelningar.</th>
<th>Jag tycker om det.</th>
<th>○</th>
</tr>
</thead>
<tbody>
<tr>
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<td>○</td>
<td></td>
</tr>
<tr>
<td>Jag är neutral.</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Jag kan leva med det.</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Jag tycker inte om det.</td>
<td>○</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Det skulle inte vara bra om jag fick bättre förståelse för andra avdelningar. (Jag skulle vara mer fokuserad på mina egna uppgifter).</th>
<th>Jag tycker om det.</th>
<th>○</th>
</tr>
</thead>
<tbody>
<tr>
<td>Det är en måste.</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Jag är neutral.</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Jag kan leva med det.</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Jag tycker inte om det.</td>
<td>○</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Det skulle vara bättre om jag fick svaret senare.</th>
<th>Jag tycker om det.</th>
<th>○</th>
</tr>
</thead>
<tbody>
<tr>
<td>Det är en måste.</td>
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<td></td>
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<td>○</td>
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<td>○</td>
<td></td>
</tr>
<tr>
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<td>○</td>
<td></td>
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<th>○</th>
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<td>Jag är neutral.</td>
<td>○</td>
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</tr>
<tr>
<td>Jag kan leva med det.</td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Jag tycker inte om det.</td>
<td>○</td>
<td></td>
</tr>
</tbody>
</table>
5) Vilka mekanismer förhindrar kommunikation?

<table>
<thead>
<tr>
<th>Mekanismer förhindrar kommunikation</th>
<th>Aldrig</th>
<th>Ibland</th>
<th>Alltid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indirekt kommunikation (formella kommunikationsvägar forsvarar kommunikation)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Konkurrens mellan avdelningar</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Olika mål</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Andra avdelningar har inte kunskap inom våra områden</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vi saknar kunskap inom andra avdelningars områden</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6) Har du yrkespraktik inom andra avdelningar?

Om du inte har yrkespraktik inom andra avdelningar, var snäll och besvara följande frågor!

Skulle du vara med på ett utbyte i 1-2 veckor?

Varför hade du inget utbyte tills nu?

7) Har dina kollegor yrkespraktik inom andra avdelningar?

8) Har medlemmar från andra avdelningar yrkespraktik inom din avdelning?

9) Skulle du skifta varaktigt till en annan avdelning, för att förbättra kommunikationen?

10) Skulle du flytta en annat kontor, för att förbättra kommunikationen? (Jobbar i den gamla avdelning, men i kontoret från den ny.)
11) Tror du att en yrkespraktik kan förbättra förståelsen för problemen inom andra avdelningar?

- O
- O
- O
- O
- O

Inte alls  kanske  Ja

12) Vad är den viktigaste förbättring enligt din mening?
### Occuring problems during communication

<table>
<thead>
<tr>
<th>Problem</th>
<th>Impression strength</th>
<th>Significance strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impersonal</td>
<td>2.71428571</td>
<td>0.02857143</td>
</tr>
<tr>
<td>Uninteresting (them)</td>
<td>2.71428571</td>
<td>0.02857143</td>
</tr>
<tr>
<td>Uninteresting (me)</td>
<td>2.57142857</td>
<td>-0.11428571</td>
</tr>
<tr>
<td>Language</td>
<td>2.68571429</td>
<td>-0.68571429</td>
</tr>
<tr>
<td>Incomplete</td>
<td>3.42857143</td>
<td>0.74285714</td>
</tr>
<tr>
<td>Too late</td>
<td>2.85714286</td>
<td>0.17142857</td>
</tr>
</tbody>
</table>

### Hinder that are responsible for the problems

<table>
<thead>
<tr>
<th>Problem</th>
<th>Impression strength</th>
<th>Significance strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indirect</td>
<td>2.57142857</td>
<td>-0.14285714</td>
</tr>
<tr>
<td>Competitive</td>
<td>2.42857143</td>
<td>-0.28571429</td>
</tr>
<tr>
<td>Different goals</td>
<td>2.57142857</td>
<td>-0.14285714</td>
</tr>
<tr>
<td>They don't know</td>
<td>2.85714286</td>
<td>0.14285714</td>
</tr>
<tr>
<td>We don't know</td>
<td>3.14285714</td>
<td>0.42857143</td>
</tr>
</tbody>
</table>
## Appendix G – Analysis of the Kano-questions

<table>
<thead>
<tr>
<th>Category</th>
<th>Total Strength</th>
<th>A</th>
<th>Better</th>
<th>Worse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kano-question 1</td>
<td>83.33%</td>
<td>14%</td>
<td>42%</td>
<td>42%</td>
</tr>
<tr>
<td>Kano-question 2</td>
<td>50.00%</td>
<td>14%</td>
<td>50.00%</td>
<td>0%</td>
</tr>
<tr>
<td>Kano-question 3</td>
<td>50.00%</td>
<td>14%</td>
<td>50.00%</td>
<td>0%</td>
</tr>
<tr>
<td>Kano-question 4</td>
<td>50.00%</td>
<td>14%</td>
<td>50.00%</td>
<td>0%</td>
</tr>
<tr>
<td>Kano-question 5</td>
<td>50.00%</td>
<td>14%</td>
<td>50.00%</td>
<td>0%</td>
</tr>
</tbody>
</table>