Selection of communication channel in multi-organizational project teams

A case study on teleconferencing and F2F communication in group meetings at Witteveen+Bos

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Preface

This paper has been written to present the results of the research conducted as a final assignment to obtain the degree of Master of Science of the master Construction Management & Engineering at the University of Twente. Conducting research regarding the utilization of specific communication channels in group meetings made me realize that the facets of project management reach even further than I had initially thought when starting this Master of Construction Management. Having contributed to this area of knowledge made me appreciate this line of work even more. It makes me even more enthusiastic to start applying my built-up knowledge during my years of studying. For this, I want to thank a number of people who helped me in finalizing my master thesis.

I would like to thank Robin de Graaf and Marc van Buiten of the University of Twente for their guidance from the start till the very end. Their insights, both practical and academic, helped me considerably in having the right focus, which made it possible to deliver this product. They were able to adjust their support to my specific needs, which I appreciate. This shows their commitment to their students which is a great trait.

I was able to conduct this research at Witteveen+Bos which made it possible to get acquainted with the work-life and to implement a practical value to the research. I want to thank Ingrid Mouwen, my supervisor at Witteveen+Bos, for her openness, trust, and effective suggestions. Because of your supervision, I was able to form my own research while reminding me of the focus of the research. Furthermore, you gave great examples that made the implicit, explicit.

Further, I would like to thank all the other people that I interviewed for their cooperation. You were always able to make time to share your knowledge which helped me considerably. I appreciate the openness and the willingness in your answers, which has given me more in-depth information.

Finally, I would like to thank my friends and family for their support during my research. The feedback and discussion about all kinds of things have provided me valuable information and encouragement to bring this thesis to an end.

Selection of communication channel in multi-organizational project teams

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Abstract

Project teams that exploit the practice of telecommunicating can reduce their travel time and save money by overcoming geographical disparity. However, the use of teleconferencing in meetings within the construction industry often fails to meet its expectations as it is not used the way it was intended. In this study, three civil engineering projects were studied and compared to theorized best practices concerning the use of teleconferencing and Face-to-Face (F2F) communication within multi-organizational project teams. This was done with a framework comprising key elements to match a communication activity with a communication channel, based on Media Richness Theory (MRT) and Social Presence Theory (SPT). The findings of the case studies endorse current literature that teams meet in person to develop their interpersonal relationship to become a well-developed team. F2F communication establishes the necessary level of trust, to overcome relational conflicts and creates commitment within a team. Teams also meet in person to negotiate widely varying opinions into a common understanding, e.g. when determining the scope of the planning, even though theory suggests this could be done with video conferencing. The results suggest that teams met in person because of the unique work settings of the construction industry resulting in the need for more real-time interaction to ensure consistency for the present-day complex projects. The case study results insinuate that audio conferencing is the leanest communication channel in situations that are highly task-focused, to not overcomplicate the processing of information. Video conferencing is used to discuss proceedings of a project and to clarify specific uncertainties in which both factual data and opinions were shared. Current literature did not suggest the leanest form of communication for the latter situation but this research has provided empirical material. However, teams still often used other means of communication than the theorized leanest communication form. It is found that people's subjective motivation to use teleconferencing over F2F interaction influences the choice of channel. This motivation seems to be influenced by other situational factors that change through time, not covered by MRT or SPT. The conditions of the construction industry appear to negatively influence this motivation, and therefore the potential of telecommunication. Teleconferencing is seen as a last resort, and not as a viable option. To improve this state of mind it is recommended to at least have a coherent reliable teleconferencing system and to enhance the conditions how people are involved in a meeting, and that promotes the culture of teleconferencing that is currently lacking. These recommendations could contribute to the normalization of teleconferencing. Lastly, this study confirms the validity of MRT and SPT as the starting point to decide on which channel to use. The addition of this research is to combine this with the other situational factors that influence a members' subjective perception to possibly make a more in-depth constructed choice of channel.

Keywords
Teleconferencing; Group meetings; Construction industry; Project Management; ICT; The Netherlands.

1. Introduction

A subject undergoing intense study in recent years is virtuality in teams [1-3]. Virtuality can be defined as the extent a group of people is using Information Communication Technology (ICT) versus meeting Face-to-Face (F2F) to communicate and collaborate across time and space [4]. The nature of work has changed significantly in the last 30 years and is nowadays increasingly performed using technology-mediated means and this is expected to only rise in the future [5]. This change of work is mainly due to the globalization of the economy, forcing businesses to adapt to new challenges and new ways of organizing work, an increase in geographical dispersion of organizations, and rapid developments in communication technologies [6,7]. Teams exploiting ICT and the practice of telecommuting could expect great promise as these teams are able to maximize functional expertise by overcoming geographic disparity and are more cost-efficient by reducing travel time [5,8]. By reducing the need to travel between work locations, it also reduces the personal stress of employees [9]. This growing awareness of the successful adoption of ICT for communication in project teams in organizations is most apparent in the industry of manufacturing such as software development, and education [4,10,11].

This development is recently adopted by the construction industry. The construction industry is criticized for problems such as the delayed delivery of products, escalated costs, and low performance [6,12]. These problems stem for a considerable part from ineffective communication [13]. Communication issues are more apparent in the construction industry as the communication process is very complex due to its unique work settings and the increasing demands for the more complex present-day projects. It is necessary to integrate a high volume of specialized knowledge of short-term partners within a project team, while being most of the time non-collocated [1,6]. This shows the importance and potential value of using ICT to communicate, especially in construction teams, as this makes it possible to integrate the geographically dispersed knowledge. Meetings are essential mechanisms for sharing information and facilitating decision making and are often used to integrate the dispersed knowledge within the construction industry [14]. Specific ICT used within meetings to communicate are audio conferencing and video conferencing as meetings imply the need for rapid two-way feedback, meaning that synchronous communication channels are needed. Audio- and video conferencing fall under the general heading of teleconferencing. The value of using teleconferencing is also represented by the heavy increase in ICT to improve knowledge and communication management in construction projects [15].

However, despite the prevalence of the use of teleconferencing in project teams, there are also fundamental challenges. E.g. potentially lower team level cohesiveness, difficulties creating trust and shared understanding, and a workplace filled with interruptions when only using teleconferencing [5]. This is due to the fact that this form of communication does not possess the same level of capabilities to convey a message compared to meeting F2F [16]. The use of teleconferencing, especially in the construction industry, often fails to meet its expectations as it is not used the way it was intended. This implies the need for adopting a fitting communication strategy, effectively utilizing both teleconferencing and F2F communication [17]. Therefore, the use of teleconferencing, complementary to or as a replacement of meeting in person, in construction projects is studied. The specific research question is: *what are current practices concerning the use of teleconferencing and F2F communication within multi-organizational project teams in the construction industry, and what can organizations do to improve the use of teleconferencing as a complementary channel to or as a replacement of F2F communication?*

The gap in theory and the developments related to teleconferencing are also apparent in current practice. The research is carried out at an Engineering Consultancy Firm (ECF). This ECF is among the top 10 engineering firms in the Netherlands playing an active role in the civil engineering industry. Their role is to offer consultancy and designs for water, infrastructure, environment, and construction projects. Within their practice, there is a higher distribution of expertise, employees work more often remote, and there is increasing resistance to traveling to a collocated location. A number of employees of the ECF see the potential of working virtually, to decrease their travel time. However, the majority of project managers within the firm have insufficient knowledge on how to utilize teleconferencing. To be able to make an informed decision on the use of teleconferencing, it is necessary to consider if the situation at hand is suitable.

To make this informed decision and to study the utilization of teleconferencing in project teams, the contingency theory is used as a framework of analysis. Contingency theory claims that the message content should fit the capability of a communication channel to transmit a message [11]. It is proposed that a message is better understood if there is a match between the communication activity and the media channel [18]. For example, to meet F2F to provide personal feedback or support to team members [2]. Communication theories that follow this fundamental principle, and provide the key elements to conceptualize the contingency theory, are Media Richness Theory (MRT) and Social Presence Theory (SPT). MRT [19] and SPT [20] emphasize that communication channels differ in their ability to transmit a message, dependent on the situation at hand. MRT refers to the difference in the richness of a channel to process information or data, similar to the capability of a pipeline to transport fluids. Richer media channels, like video conferencing, can transmit a higher amount of equivocal information (e.g., with its ability to convey body language), whereas leaner media channels, such as e-mail, cannot. SPT refers to the degree to which a channel can establish a sense of intimacy and physical presence. Channels that are able to establish this social presence enhance the socioemotional aspects of communication [20]. For example, in general people meeting F2F discuss more informal topics in comparison to meeting with audio conferencing. Both MRT and SPT are used because, as pointed out by Kupritz and Cowell [21], the central premises of these theories have been proven to be valid and relevant. These theories are still used in recent studies about the utilization of different communication channels and in the educational environment.

The contribution of this research is twofold. The first contribution is to test the relevancy of the MRT and the SPT in the environment of the construction industry. Both theories have proven their value in the educational environment, but there is a lack of empirical studies in the organizational environment and more specifically in the construction industry. The second contribution is aimed at practice how organizations and managers can improve the utilization of teleconferencing as a complimentary channel to or as a replacement of F2F communication in multi-organizational project teams.

This paper is structured as follows: MRT and SPT are further described in the next section. This is followed up by the section where the framework is developed to analyze three projects. Then, the research design is addressed in the section of the research method. The results, the discussion including implications for further research, and lastly the conclusions and recommendations are presented in the subsequent sections.

2. Media Richness Theory & Social Presence Theory

The essential underlying principle in both MRT, developed by Daft and Lengel [22], and SPT by Short et al. [20] is based on the theory of contingency. This underlying principle suggests that a match between the characteristics of a media channel and one's communication activities will lead to more effective communication and therefore better understanding [11]. Both MRT and SPT describe that media channels differ in their capacity to transmit a message. This capacity of a media channel is described in theory as **media richness**. Media richness is a continuum, varying from the richest channel being F2F communication to the leanest media being a formal report. A richer media channel can transmit a higher amount of equivocal information and can establish a higher sense of intimacy and physical presence. The information sent through a channel is described in theory as the **message content**. The message content is influenced by the situation at hand, in other words, the characteristics of the task described by MRT, and the interpersonal relationship between individuals involved described by SPT. The message content varies from routine messages, that are simple and straightforward, to complex, messages that involve great potential for misunderstanding.

The most effective matching of message content to media richness is not to overcomplicate or to oversimplify. Oversimplification means that the communication channel's richness is too low and is not able to transmit the information, leading to a higher chance of a misunderstanding [18]. Overcomplication means that the used communication channel is too rich for a routine message, leading to distractions from the task-focused subject and over-commitment of resources such as time and money [22]. A communication channel is too rich if there are too many cues involved, either verbal or non-verbal. Cues are signals transmitting information. Verbal cues are the spoken words and non-verbal cues are for example body language, tone, and facial expressions [11]. There is a bandwidth of effective communication, or information processing, as two different communication channels could both suffice in a specific situation. The fundamental choice to decide what communication channel to use represented by the relation between media richness and message content, depicted in Figure 1, enables substantiated decision-making. The aspects of media richness and message content according MRT and SPT are described in more detail in the next sub section.

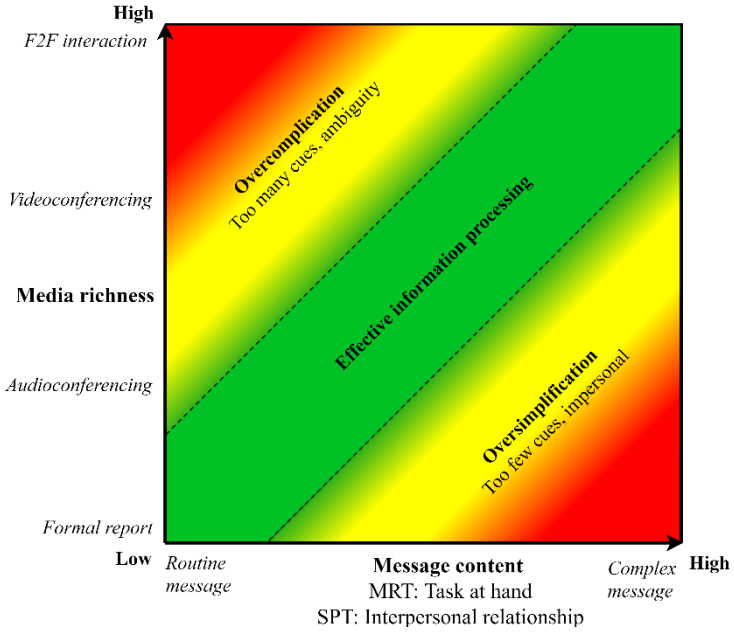

Figure 1 Relation between message content and media richness adapted from Daft and Lengel [22]

2.1 Media richness

The richness of a channel is the capacity of a channel to transmit equivocal information and to establish a sense of intimacy and physical presence [20-22]. The richness is influenced by three characteristics; (1) the ability to handle multiple cues simultaneously (verbal and/ or non-verbal), (2) the ability to facilitate rapid two-way feedback (asynchronous or synchronous), and (3) the ability to establish a personal focus for the communication [18]. Participants in a conversation have an improved emotional understanding of the situation if the personal focus is established. F2F is the richest form of communication that can convey all types of cues (verbal and non-verbal), is able to facilitate immediate synchronous feedback, and can establish a high personal focus. Both the conveyance of cues and the speed of feedback are objective indicators, whereas the personal focus is more subjective. As stated by Daft and Lengel [19], a personal focus is established more fully when it becomes possible to infuse the message with personal feelings and emotions, which cannot be explicitly labeled. However, empirical research has provided an indication of this ability for different media channels [17]. The specifics of the characteristics for media channels and their indicators are summarized in Table 1.

Table 1 characteristics of media channels

Characteristic media channel	Indicator
1. Handling multiple cues simultaneously	I. Verbal a) Spoken words II. Non-verbal a) Vision (e.g., body language and direction of gaze); b) Vocal (e.g., pitch and tone); c) Touch (e.g., touching and shaking hands); c) Smell (e.g., smells and body odor) [21].
2. Facilitation of rapid, two-way feedback	I. Synchronous (immediate feedback). II. Asynchronous (no permission, flow, or fast feedback);
3. Establishing a personal focus	Including personal feelings and emotion (subjective)

In this research the following communication channels are considered, in order of richness from highest to lowest; (1) F2F communication, (2) video conferencing, and (3) audio conferencing. The latter two channels fall under the general heading of teleconferencing. The literature study provided the media richness level of each researched channel, described in Table 2, in alignment with the aspects provided in Table 1.

Table 2 Media richness of communication channels

Channel	Cues conveyed	Feedback	Personal focus
1. F2F	All verbal and non-verbal cues	Immediate feedback (Synchronous)	Permits direct experience, the highest level of personal focus
2. Video conferencing	Vision (two-way eye contact is limited), verbal, and vocal	Immediate feedback (Synchronous)	Video capabilities provide a certain personal focus
3. Audio conferencing	Verbal and vocal	Immediate feedback (Synchronous)	Only audio capabilities, providing less personal focus than video conferencing

2.2 Message content

The message content is the information that is transmitted through a media channel influenced by the situation at hand. Whereas MRT is solely focused on the communication about the task, SPT aims its attention on the relational aspect of a team. The situation at hand influencing information processing according to MRT, as suggested by Daft and Lengel [22], is based on the two forces of equivocality and uncertainty. Equivocality is described by Daft and Lengel [19], p. 556 as "the existence of multiple and conflicting interpretations about a situation." In other words, ambiguity and therefore the possibility of misunderstanding as the topic may be perceived differently by employees. Uncertainty is defined by Daft and Lengel [19], p. 556 as "the difference between the amount of information required to perform the task and the amount of information already possessed by the organization". The central premise of uncertainty is that new data can be acquired so that tasks are performed under a reduced level of uncertainty. According to MRT, the determinants that express equivocality and uncertainty are (1) the complexity of the task and (2) the interdepartmental relationship. These determinants specify the conditions for the choice of communication channel about the task at hand. The complexity of the task specifies the analyzability of the task, and the interdepartmental relation, i.e. the connection between departments, specifies the level of integration across departments [22]. For example, a complex problem with a high need for integration across departments implies an issue that is difficult to analyze and unpredictable, accompanied by the requirement to integrate a vast amount of subjective information of contrasting departments within a project team.

According to SPT, as suggested by Short et al. [20], information processing is influenced by the relational aspect of the team founded on the forces of open communication and trust. This is related to the interpersonal relationship between involved members. Open communication within a team establishes transparency and affects the connectedness within a team [23]. Trust within a team holds interpersonal relationships together as it is the willingness to accept and comply with other individuals' actions [8]. The determinant that expresses open communication and trust is team maturity. Team maturity is the extent to which the members involved in the project are committed to the team and can collaborate together [24]. This determinant specifies the conditions for the choice of communication channel about the relational aspect of a team. For example, a team that is immature, or under-developed, should focus on building the interpersonal relationship to have a successful partnership [25]. There is, in general, a higher level of trust and a culture of knowledge sharing in case groups are developed [6]. Concluding, the mentioned determinants influencing the information to be transmitted are; (1) complexity of the task, (2) interdepartmental relationship, and (3) team maturity, and are summarized in Table 3 and described more in detail below.

Table 3 Variables influencing the information that must be transmitted

Determinant message content	Variable	Theoretical characterization
Task complexity	The subjectivity of cues used to transmit information	MRT (Equivocality)
	Extent the event is defined	MRT (Uncertainty)
Interdepartmental relationship	Reference of Frames (RoF)	MRT (Equivocality)
	Interdependency between individuals, departments, or organizations	MRT (Uncertainty)
Team maturity	Need for interpersonal skills	SPT (Open communication)
	Team cohesion	SPT (Trust)

Task complexity

Subjective cues express a person's opinion or personal judgment, conveyed by non-verbal cues such as body language and vocal tone. In other words, it is open for interpretation. Objective cues do not include socioemotional elements, i.e. it is factual data [26]. For example, answers to yes/ no questions or to a survey. The higher the level of subjective cues, the greater the possibility of ambiguity. To which extent an event is defined influences uncertainty. When a task is ill-defined, an organization or project team needs additional information about many issues to make decisions. For example, when a team starts a new task or after major scope changes. The project team then needs to allocate tasks and responsibilities to team members, followed up by the collection and integration of the data into a product to conclude it. Uncertainty decreases as project members work on the task by collecting data, making it possible to make decisions. A project team has the data to answer the questions to the variables in case a task is well-defined [19].

Interdepartmental relationship

A frame of reference is the background of an individual, for example, their functional specialization that influences their train of thought. Within project teams, there are widely varying disciplines, each with their own functional specialization, who need to work together. The difference in Reference of Frames (RoF) leads to ambiguity as each discipline has its own perception of an issue. Therefore, as variance in RoF increases, equivocality increases as well. The extent to which individuals, groups or organizations depend on each other, influences the level of uncertainty. Interdependency is an element that is typical for the construction industry due to its high complexity projects in which many disciplines must work together towards a common goal [27]. When activities of one discipline influence other areas, then information must be shared between them to ensure an integrative product. This implies that the higher the interdependency, the higher the uncertainty as an action by one individual can force adaptation by other individuals within the team [19].

Team maturity

Interpersonal skills are the skills related to a persons' Emotional Intelligence (EQ) influencing their social awareness [28]. Social awareness fosters openness of communication within a communication activity. Interpersonal skills are needed in activities such as motivating team members, and to enlist cooperation with the parties involved in a project team [18]. This fosters openness, honesty, and trust. Exchanging standard procedural information requires no interpersonal skills [29]. Cohesion is a dynamic aspect of a team that changes through time and is, in other words, a sense of group commitment and sense of belonging. Groups that are well-developed are more confident to express socioemotional acts with leaner channels to manage their relationships increasing the level of trust and a culture of knowledge sharing, whereas under-developed groups are not [6].

3. Towards a framework of analysis

The previous section described the aspects related to the choice of a communication channel based on MRT and SPT. This is the richness of a media channel and the message content influenced by three main determinants; task complexity, interdepartmental relationship, and team maturity. In this research, the relation between media richness and message content, shown in Figure 1, was adapted from MRT as this conceptualization has been proven to be a valid instrument in both theory and practice [21]. The only adaptation made to this relation has been the addition of SPT to include team maturity as a determinant for the message content because MRT focuses solely on the specifics on the task. Project teams in the construction industry are short-term partners with a lack of prior history that need to work together towards a shared objective. To have a successful partnership there is a need to develop a relationship composed of trust. This is best developed by communicating with rich channels [25]. This is acknowledged by Sunwolf and Frey [30], stating that developing a positive interpersonal relationship is an important concept of teamwork. Therefore, if team maturity is excluded, it could result in a misplaced selection of a communication channel, especially in the construction industry.

These beforementioned aspects about the choice of a communication channel are operationalized into a framework to analyze current practice. This is established by reviewing current literature about the choice of communication channels

within meetings in various industries. Research within the civil engineering sector has not led to the necessary insights on this subject. First, the three determinants that influence the information to be transmitted, i.e. the message content, were analyzed to distinguish situations in practice that can be connected to the choice of a communication channel. Thereafter, suggestions for the choice of communication channels, based on the specifics of the three determinants, were analyzed in current literature. This combined formed the theoretical framework for the selection of a communication channel in multi-organizational project teams.

3.1 Operationalization of the three determinants influencing the message content

MRT literature provided the information to describe the situations for the determinants related to communication about the task at hand, i.e. task complexity and interdepartmental relationship. However, SPT literature did not provide the necessary information about the determinant related to the relational aspect of the team. To fully operationalize the situations about team maturity it was necessary to include the closely related theory about team development developed by Tuckman [31]. The theory of group development suggests that a team develops their interpersonal relationship through time, becoming more cohesive based on the aspects of open communication and trust. This corresponds to the description of team maturity by SPT. The theory of Tuckman [31] is also the most predominantly referred to and is the most widely recognized theory in team development literature [32]. The addition of team development theory to SPT made it possible to operationalize the relational aspect of a team influencing the message content.

In this literature, only extreme levels of the three determinants could be distinguished. In other words, low and high levels and not the intermediate levels. 'Low' indicates the need for leaner channels, such as audio conferencing, whereas 'high' indicates the need for richer channels like F2F communication. These levels are the measurable indicators that are used to distinguish specific circumstances in current practice. The framework that serves as a directory to distinguish situations in practice is summarized in Table 4. It describes the three determinants, the variables per determinant, and the measurable indicators. Furthermore, examples of key questions are provided to show how low- and high-level situations are identified within group meetings.

Table 4 Framework of analysis for the message content

Determinant	**Variable**	**Low level**	**High level**	**Examples of key questions**
Task complexity	- The subjectivity of cues used to transmit information - Extent the event is defined	1. A clear well-defined situation; 2. No ambiguous or unclear events exist; 3. The goal of the meeting is endorsed by participants; 4. The few required answers can be gathered through routine objective data [19].	1. An ill-defined situation; 2. Many ambiguous and unclear events exist; 3. Participants may disagree over the goal of the meeting; 4. The many required answers are gathered by exchanging subjective data that is open for interpretation [19,22].	- Is the task at hand talked over by ideas and opinions or by routine data, i.e. questions that can be answered by yes or no? - Was it necessary to define the scope of the task within the session, i.e. to define the problem and to reach an agreement or was the scope of the task clear?
Interdepartmental relationship	- Reference of Frames (RoF) - Interdependency between disciplines, or organizations	1. There is a low variety of RoF; 2. Disciplines or organizations work independently; 3. There are no wide differences to be resolved; 4. A low volume of data must be processed to enable mutual adjustment [19].	1. There is a wide variety of RoF (e.g. distinct functional skill sets); 2. Disciplines or organizations are reciprocal interdependent; 3. Wide differences must be resolved; 4. A high volume of data must be processed to enable mutual adjustment [19,22].	- How many different organizations were involved in the meeting? - Was there a shared understanding between the disciplines with which to solve problems or are there wide differences in opinion? - Were the organizations or disciplines able to work independently or was it necessary to enable mutual adjustment by exchanging all information?
Team maturity	- Need for interpersonal skills - Team cohesion	1. Team structure and purpose are already defined and there is no relational conflict [31,33]. 2. Cooperation and commitment are already established with involved parties [29].	1. Team structure and purpose need to be defined, or during a relational conflict [34]. 2. It is necessary to establish cooperation or to create commitment with involved parties [18].	- Were team members focusing on the task or was there still uncertainty related to the group's purpose and structure, or even relational conflict? - Had the meeting a function to create commitment for the project or to establish a culture of cooperation with the involved parties?

Table 4 provides eight different situations (the combinations of the specific conditions) by making combinations of the three determinants with either a low or high level. In other words, two variables for each of the three determinants, which gives $2^3 = 8$ options. For example, option 1 is the one extreme where all three determinants are of a high level. For instance, a project team with no prior experience that is at the start of a project. The goal of the project must be determined

with a group meeting, meaning the task is ill-defined. The team members exchange their opinions, that are possibly opposing, that follow from their different backgrounds because there are different organizations that must work together, and the members have varying functional skill sets that must be integrated into one shared understanding. On the other end, option 8, is the extreme where all determinants are low. The structure of the team is already well established, and members are therefore transparent in their communication and can actively help each other with leaner channels. There is a high focus on the task, i.e. the goal and the way to reach the goal are already clearly defined. Furthermore, tasks and responsibilities are already allocated, and the members are aware of this. This means that there is already a shared understanding and that members can work independently towards a common goal. The minor uncertainties can be solved by exchanging objective data, such as the answer to the question if the planning is still on schedule.

3.2 Recommended media channel based on the situation at hand

According to MRT and SPT, the most effective matching of the message content with a channel is not to overcomplicate or to oversimplify. In other words, the used channel should be able to transmit the information without creating a high risk of misunderstanding but should not lead to distractions from the task or to overcommitting of time and money [18,22]. This means in practice, that the leanest media channel should be applied that is still able to transmit the information without a high risk of misunderstanding. The leanest communication channel according to current literature for each of the eight situations is described in Table 5. This is the framework for analysis, together with Table 4, that is used to analyze current practice. Additional information for each option is provided below.

Table 5 Recommended leanest possible channel(s) according to media richness and social presence theory

Message content **1. Task complexity** **2. Interdepartmental relationship** **3. Team maturity**	**Theoretical pattern(s)** **(Leanest possible channel and reasoning)**	**Sources**
Option 1, 2, 3, and 4 **(High maturity level)** 1. Task: High or low 2. Departmental: High or low 3. Maturity: High	**F2F** F2F communication allows the team to overcome the relational conflict, effectively establishes group norms and trust, and/ or it can create commitment within the team and can establish cooperation with involved parties.	[2,6,18,21,30,33, 35-39]
	F2F communication is recommended as the beforementioned aspects are accomplished largely through non-verbal cues and it makes it possible to have an emotional understanding of the situation.	[16,18,34,40]
Option 5 1. Task: High 2. Departmental: High 3. Maturity: low	**Video conference** There is a need for visual cues when the opinions, following from a wide variety of RoF, of a group of people who are reciprocal interdependent must be negotiated. It excludes the use of audio conferencing.	[2,11,19,38,40, 41]
	F2F interaction does remain the most ideal medium for small group discussions in case both the task complexity and interdepartmental relation are high.	[3,40,42-44]
Option 6 1. Task: Low 2. Departmental: High 3. Maturity: Low	**Video conference** When the task at hand is already well-defined and data collected is mostly of objective nature while there is still a high level of interdepartmental relation, i.e. decision making more focused on the task, the possibility to apply video conferencing becomes better substantiated.	[19,39,45]
	F2F communication is especially preferred for tasks that require a high level of coordination, i.e. high interdepartmental relation, in case the team does not have the knowledge to effectively use video conferencing.	[42,43]
Option 7 1. Task: High 2. Departmental: Low 3. Maturity: Low	**Audio conference** When there are many ambiguous and unclear events, while the team can work independently and have already reached a shared understanding, it is not suggested to use a specific type of communication channel. Both F2F communication and teleconferencing could be applied.	[2,9,39,45,46]
	The choice of what communication channel to use in this case relies highly on the preference of the team and other situational factors.	[8,9]
Option 8 1. Task: Low 2. Departmental: Low 3. Maturity: High	**Audio conference** When it is more routine communication interaction, i.e. common planning and task-focused decision making, then it is suggested to use audio conferencing to increase the focus on the task as it conveys fewer cues.	[17,26,38]

High-level team maturity (Option 1 to 4)

The literature highly suggests using F2F communication in situations when a team is under-developed, regardless of the other determinants. This implies that meeting F2F is a boundary condition. Therefore, the options with a high level of team maturity, options 1 to 4, are collated in Table 5. This is in situations where there is still great uncertainty regarding the group's purpose and its structure, or during a relational conflict. The team actively shares personal information and specifics about the task to increase team cohesion and it is possible that conflicts emerge related to interpersonal issues [33,34]. This also applies to situations where it is necessary to establish cooperation with the parties involved, to create commitment or to motivate members [34]. These interactions are mostly transmitted through non-verbal cues such as body language, and mutual gaze, establishing a high personal focus best conveyed by F2F communication as validated by Short et al. [20] and Tuckman [31]. This implies that meeting in person is highly suggested in these situations.

High-level task complexity and interdepartmental relationship (option 5)

In this situation the task is ill-defined, and members involved in the meeting have a wide variety of RoF and are reciprocally interdependent. This could, for example, occur when the scope of a project needs to be determined within a meeting. It must be defined by integrating the differentiating opinions of the team members, following from varying backgrounds (e.g. varying skill sets and organizations), to reach an agreement on the specifics of the task. The different opinions are pooled and agreed upon by discussion and negotiation, which establishes a shared understanding. The literature suggests that in this situation, focused on negotiating different opinions of a group into a common perception, the information can be transmitted if visual cues are available [38]. Removing visual cues namely impairs the accuracy of a person's perception decreasing understandability [40]. This excludes the possibility of audio conferencing but does not exclude video conferencing as a proper channel. However, if both task complexity and interdepartmental relationship are high, then F2F interaction does remain the most ideal medium to handle the complex interaction of information [44].

High-level interdepartmental relationship (option 6)

Members involved in the meeting have a wide variety of RoF and are reciprocally interdependent, but the scope of the task within the meeting is already clear. An example situation is a task conflict, i.e. team members have differing opinions on how the task should be done while the scope is already clear. The difference in opinion originates from either being from a different organization and/ or having a different skill set. An agreement is reached by negotiating and discussing the different opinions into a common understanding. The decision-making is more focused on the task at hand, and therefore video conferencing becomes better substantiated in comparison to option 5 [45]. The decision to either apply F2F or video conferencing for the group meeting, in this case, depends on the more nuanced level of the task complexity and interdepartmental relationship but is not described by MRT or SPT. It also depends on other factors such as the level of geographical distribution, as video conferencing saves on participants' travel time and costs whereas meeting in person does not [39].

High-level task complexity (option 7)

There are many ambiguous and unclear events and participants may be in disagreement but there are no wide differences to overcome and there is no need for mutual adjustment as disciplines can work independently because there is already a shared understanding. An example in practice could be a meeting with a specific discipline with a similar RoF while working on a task not related to other aspects of the project. Nevertheless, the task at hand is not defined and must be determined within the session. This is established by rational data collection and by exchanging both ideas and opinions, to define the problem, and to reach an agreement on the solution for the task at hand [22]. In this situation, the literature is not prescribing a specific communication channel. According to literature, teams should be able to apply both video conferencing and audio conferencing for the task at hand in case minimal integration of information is necessary; i.e. a low interdepartmental relation [19]. However, F2F is also still a feasible option if there is a stronger preference within the team to meet in person. In this case, it is possible to alternately use F2F communication and teleconferencing [9]. The empirical material could indicate if there are specific preferences and if audio conferencing is indeed the leanest communication channel to be used.

Low-level determinants (option 8)

Current literature prescribes audio conferencing when all determinants are low, implying a more routine and not a complex communication interaction [2]. An example of such a task is common planning and decision making. Using audio conferencing will lead to better decision making due to the filtering of social cues. It increases the focus on the task [17,26]. In other words, a richer communication channel would lead to overcomplication and therefore over-commitment of travel time and money.

The framework described in Table 5, supported by Table 4, provides the necessary information to analyze current practice. The relevance and accurateness of the suggestions by theory should also be determined in the case studies. The case studies should provide a better understanding of the different options described by the theoretical framework.

4. Research method

A theoretical framework has been established by carrying out the literature research as described in the previous two sections. To determine what organizations can do to improve the utilization of teleconferencing as a complementary channel to or as a replacement of F2F communication in group meetings, this framework has been compared to current practices. As described in the theoretical framework, the practices are focused on communication in group meetings in projects and not on an organizational level. To analyze current practices, with specific contextual conditions, a case study research was conducted [47]. This is because the research is of exploratory nature, to investigate current practices and to provide recommendations. Furthermore, the studied projects are contemporary and researchers have no control over the events [47]. This study is carried out in three civil engineering projects in the Netherlands. There is a focus on group meetings as these are essential mechanisms for sharing information and facilitating decision making to integrate the dispersed knowledge within the construction industry [14]. This implies that only the channels; F2F, video conferencing and audio conferencing are considered because of the need for facilitation of rapid two-way feedback. The considered meetings are those focused on the aspects of project control, more specifically planning- and risk management. This made it possible to achieve depth, by excluding other types of meetings, and to reduce the number of variables studying the three projects. Results from these specific meetings are generalized to other types of group meetings.

Data were collected by means of document analysis, semi-structured interviews, and observations. By cross verification of the different data sets, data triangulation is ensured. The results of the case studies are compared with the theoretical framework by pattern matching [48]. This is about comparing the pragmatic reality with the theoretical ideals [49]. This made it possible to identify the similarities and differences between theory and practice. Pattern matching was applied as it is a recommended strategy for qualitative analysis for case studies. Based on the findings, recommendations are explicated on the use of teleconferencing and F2F communication within group meetings. The main findings and recommendations are validated with a focus group, that consisted of members that were already interviewed and are therefore knowledgeable of the context of the research.

4.1 The projects

In the three studied civil engineering projects, all in their exploration phase, a combination of F2F and teleconferencing was used during group meetings. In all projects, the teams made use of the Integrated Project Management (IPM) teams, carried out similar project control tasks based on the 'Product Catalogue Project Control'[1], and are multi-organizational. It was intended to have a focus on projects that are part of the flood protection program of the Netherlands. However, the data set only provided two projects in the flood protection program where the project team wanted to provide full cooperation. Therefore, another project was included that did fit the other variables. These three projects have been selected to control as many variables influencing a dependent variable, to enable more reliable data [50]. The industry, the project phase, and the type of meetings are isolated variables. The projects do differ in size and the geographical distance differentiates between the parties involved. Thus, the three cases provide an extensive perspective of current practices on the use of F2F and teleconferencing in meetings while taking the influence of the size of a project and the geographical distance between parties involved into consideration.

- Project A is a dike reinforcement project, part of a flood protection program in the Netherlands. The project team consisted of the client and an ECF who developed the preferred alternative for the realization. There was a geographical disparity between team members of the ECF and between the ECF and the client.
- Project B is a dike reinforcement program, consisting of several projects. The project team consisted of three organizations; the client, and two ECF's who were in a limited partnership. The partnership developed the preferred alternative for the program and the first two projects within the program. The three parties within the project team are dispersed over the Netherlands.
- Project C is a maintenance project of mooring facilities in one province of the Netherlands, as part of a program. The project team consisted of several parties as the client contracted an ECF, who subcontracted several agencies. The contracted parties analyzed the current state of the facilities and wrote the contract for the tender. There was only a considerable geographical distance between the subcontracted parties and the rest of the project team.

4.2 Data collection

During the case studies, current practices on the utilization of both F2F communication and teleconferencing in group meetings were compared to theory. The empirical data is collected by means of document analysis, interviews, and observations. Each project's action plan was analyzed to determine the organizational and communication plan. This

[1] The Product Catalogue Project Control are the main guidelines of Rijkswaterstaat, the Dutch Ministry of Infrastructure and Water Management, specifying the products of planning- and risk management to be carried out by the contracted party.

provided the necessary background about the characteristics of the project and the scheduled formal meetings. The next step was to determine current practices on the use of communication channels based on the framework of MRT and SPT. By conducting 18 semi-structured interviews, 6 for each case, it was possible to map the current practices and the influence of the situation at hand on selecting the preferred communication channel. The people that were interviewed are of a strategic sample, i.e. chosen for their distinctive characteristics. In each project, the project manager, the manager project control, the contract manager, and the environmental manager were interviewed after the project had already been carried out. These specific people were interviewed, as they were part of the integrated project management team representing the key players of the project team influencing the communication plan and therefore the choice of which communication channel to use. The specific protocol that guided each semi-structured interview is supplied in Appendix A. The theoretical framework was used to scope the answers of the interviewee in accordance with the context of the research. The conditions of the situation at hand and the choice of communication channel based on that situation is the context in this research. Example questions to identify the level of the determinants of the situation are provided in Table 4. These were followed up by questions to determine the rationale of a communication channel. For example, *"What was the specific reasoning for choosing this communication channel in that situation and does this change through time?"*. The observations were applied to give an insight into the actual practice and how this related to the answers of the interviewees. The combination of the collected data made it possible to validate and refine the findings. Finally, experts of the civil engineering industry reviewed the results of the research in the form of a focus group. This was done by presenting the main results and recommendations of the research. This was followed up by an open discussion led by one of the experts to ensure that the discussion was not influenced by the researcher.

4.3 Data analysis

The collected data in this research are of a qualitative nature. The data collected by the case studies are analyzed by means of pattern matching, to compare the current use of communication channels within group meetings to what should have been done according to MRT, SPT, and the theory of team development. Pattern matching is recommended as a strategy for qualitative analysis for case studies. It is about comparing the pragmatic reality with the theoretical ideals [49]. The matching is based on a three-point scale, (-) indicating a mismatch, (O) a partial match, and (+) a match. Matches represent coherent choices of the leanest possible channel based on the specific situation between theory and practice and mismatches the incoherent choices of a channel. Finally, partial matches represent the situations in which multiple channels are used but one of the channels does correspond to the theorized leanest possible communication channel. A lack of evidence to determine either a mismatch or mismatch between theory and practice results in no status, i.e. there is no available statement (N/A). Furthermore, empirical statements are provided to give context to the comparison of the patterns. The empirical pattern and the theoretical pattern are compared in terms of the eight different options as provided in Table 5, i.e. the theoretical framework provided in section 3. The conclusions of these comparisons have resulted in the recommendations for the utilization of teleconferencing as a complementary to or as replacement of F2F communication in group meetings.

5. Results

This section describes the pragmatic reality of the three projects from which the empirical pattern is derived. The empirical pattern is described in the same elements as the description of the theoretical pattern shown in Table 5. The analysis of the results explains the commonalities and differences between theory and practice, and across the cases.

5.1 Case study results

Table 6 summarizes the results of the three projects by means of pattern matching to confront the theoretical framework with current practices [48]. The pattern matching is scored per option by a three-point scale (-/O/+). Detailed information underlying this table, the pattern matching for each separate project, can be found in Appendix B, Table B.1, Table B.2, and Table B.3. The results are analyzed and explained in the following subsection. This sub-section, the analysis of the results, is divided into matches (+), partial matches (O), and mismatches (-) to generalize the findings of the individual projects into one general perspective of the current situation.

There is a lack of evidence for option 7 and the data point of case B for option 8. There were no group meetings in this data set with many ambiguous events, but no variance in RoF and where the members within the meeting could work independently from the rest of the project team. This does not mean that this situation cannot occur, it just did not take place within the researched projects. Option 7 is therefore excluded from the analysis of the results. This also applies to the missing data point in case B. This is further discussed in the limitation of the research.

Table 6 Theoretical versus empirical pattern – the choice of a communication channel

Message content **1. Task complexity** **2. Interdepartmental relationship** **3. Team maturity**	**Theoretical pattern(s)** **(Leanest possible channel and reasoning)**	**Case A**	**Case B**	**Case C**
Option 1, 2, 3, and 4 **(High maturity level)** 1. Task: High or low 2. Departmental: High or low 3. Maturity: High	**F2F** F2F communication allows the team to overcome the relational conflict, effectively establishes group norms and trust, and/ or it can create commitment within the team and can establish cooperation with involved parties. F2F communication is recommended as the beforementioned aspects are accomplished largely through non-verbal cues and it makes it possible to have an emotional understanding of the situation.	F2F (+)	F2F or audio conference (O)	F2F (+)
Option 5 1. Task: High 2. Departmental: High 3. Maturity: low	**Video conference** There is a need for visual cues when the opinions, following from a wide variety of RoF, of a group of people who are reciprocal interdependent must be negotiated. It excludes the use of audio conferencing. F2F interaction does remain the most ideal medium for small group discussions in case both the task complexity and interdepartmental relation are high.	F2F (-)	F2F (-)	F2F (-)
Option 6 1. Task: Low 2. Departmental: High 3. Maturity: Low	**Video conference** When the task at hand is already well-defined and data collected is mostly of objective nature while there is still a high level of interdepartmental relation, i.e. decision making more focused on the task, the possibility to apply video conferencing becomes better substantiated. F2F communication is especially preferred for tasks that require a high level of coordination, i.e. high interdepartmental relation, in case the team does not have the knowledge to effectively use video conferencing.	F2F (-)	F2F (-)	F2F (-)
Option 7 1. Task: High 2. Departmental: Low 3. Maturity: Low	**Audio conference** When there are many ambiguous and unclear events, while the team can work independently and have already reached a shared understanding, it is not suggested to use a specific type of communication channel. Both F2F communication and teleconferencing could be applied. The choice of what communication channel to use in this case relies highly on the preference of the team and other situational factors.	N/A*	N/A*	N/A*
Option 8 1. Task: Low 2. Departmental: Low 3. Maturity: High	**Audio conference** When it is more routine communication interaction, i.e. common planning and task-focused decision making, then it is suggested to use audio conferencing to increase the focus on the task as it conveys fewer cues.	Audio (+)	N/A*	Audio (+)

*The empirical material for this data point is unavailable and is therefore not commented on in the analysis of results.

5.2 Analyzing the results

Matches and partial match (Option 1-4, and 8)

The pattern matching indicates that F2F communication, and not teleconferencing, is used for option 1 to 4 in projects A and C. In project B, the team did use audio conferencing on rare occasions (therefore partial match) discussing the progress of the two projects within the program that were under a high time pressure, i.e. a critical topic. It was necessary to show commitment and to maintain the collaboration. The specific reason to use audio conferencing was to include a manager who was unable to attend the meeting in person. However, project members did mention that there were misunderstandings in this conversation due to the use of audio conferencing, implying that the media channel was too lean for this situation. Still, all meetings in project A and C, and most meetings in project B, corresponding to the situation described in option 1 to 4 were carried out in person. Teams met in person to overcome relational conflicts, to establish the group norms and trust, i.e. team cohesion, and to create commitment within the project team. Examples of such meetings are the Project Start-Up (PSU) and the negotiation about conflicts concerning the contract between the client and the contracted party. The teams also met F2F creating the initial schedule and risk dossier to establish commitment within the project team. The project teams worked on their team maturity in these meetings to become a well-developed team to eventually collaborate more proficiently. The teams were still getting used to collaborating together as there was no prior experience. The project members described that interacting F2F provides an indication of the emotional status of

the situation which was necessary within the beforementioned situations. F2F interaction can convey a high enough level of personal focus, as it conveys all non-verbal cues. Video conferencing is, according to the project members, too lean to develop team maturity. It does not capture the necessary emotional status, impairing the conversation.

Audio conferencing is used in situations matching option 8. It is applied in situations when it was a more routine communication interaction, i.e. highly task-focused decision making. No extensive discussion was required; thus the few variables could be answered by gathering factual data, and there was already a shared understanding within the team. In project A and C, the members used audio conferencing to either discuss progress on a specific work track when most uncertainties had already been clarified or to discuss specific uncertainties focused on the task that could not be solved by e-mail. The reasoning to specifically use audio conferencing was to exclude visual cues, as more cues would have led to distractions from the task at hand. As explained, video conferencing would have already led to overcomplication.

Mismatches (Options 5 -6)

The theoretical patterns of options 5 and 6 are not matching with the empirical results. The theoretical framework suggests that video conferencing is the leanest communication channel to be used when a group of people needs to resolve wide differences, originating from a difference in background, and who are reciprocal interdependent regardless of the extent the task at hand is defined. However, in all projects only F2F communication has been used in these situations. The project members explained that the inherent complexity of the construction industry makes it more difficult to coordinate information. Within the projects, it was necessary to integrate all separate products, from a plan to manage the stakeholders to the technical design of the project, into a common product. Furthermore, the developed product needed to be aligned with the wishes of the client. In other words, a necessity for real-time interaction in combination with high time pressure made it more difficult to coordinate information in this specific industry in comparison to other industries.

As for option 5, the project teams met F2F in situations where the task was ill-defined, i.e. many ambiguous events, and where members had a wide variety of RoF and were reciprocally interdependent, to negotiate their opinions. Every team met F2F to develop the initial schedule and risk dossier. So, to define the scope of the project within the meeting, and to map the interdependencies and the responsibilities, a shared understanding is created. The project members who were from different organizations and had different skill sets needed to integrate their ideas by discussing many ambiguous events, such as all possible risks in a project, to come to a final agreement. To integrate the expertise of all team members it was highly preferred to meet F2F to diminish the risk of overlooking interdependences as leaner channels were suggested to be unable to convey this amount of information. Teleconferencing would have introduced a risk of misunderstanding that was not preferred as it could have reduced the project developments' consistency.

As for option 6, the teams also met in person when there was a wide variety of RoF and members are reciprocally interdependent, even though the scope of the task was already clear. In project A there was a task conflict, between client and ECF, over the level of detail that needed to be delivered by the ECF. The team met specifically F2F to overcome the wide differences in opinion that needed to be integrated together, to eventually create a shared understanding. The differing opinions stemmed from the varying functional expertise and the different organizations that needed to work together towards a common goal in a project team. The coordination of the information in these situations appeared to be more difficult with leaner media based on previous experience. The interviewees suggest that teleconferencing would oversimplify meetings corresponding to options 5 and 6 and as a result introduce the risk of misunderstanding that is rather averted. Consistency is preferred as risks could result in high losses within these complex projects.

5.3 Additional findings

An additional finding within this research is the reasoning for the choice of a communication channel in case the determinants; task complexity, interdepartmental relationship, and team maturity, are intermediate instead of just low or high. Current literature did not provide the specifics for the choice of the leanest possible communication channel for these situations. Practical examples are; progress meetings, that follow up on the initial meetings to scope the task, and more spontaneous meetings to clarify in-depth uncertainties. The empirical results of these situations are provided in Appendix B, Table B.1, Table B.2, and Table B.3 under options 9 and 10. The choice of which communication channel to use in these situations differentiates per project. It appears that there are other situational factors outside the theoretical framework influencing the choice of a media channel. According to the project members, this is related to their general motivation to use teleconferencing over F2F interaction. These additional findings are further explained in the following section, the discussion, where the findings are reviewed and reflected upon by reviewing current literature.

5.4 General overview

Concluding, firstly, it is considered a boundary condition to execute meetings F2F according to both theory and practice when project teams need to establish group norms and trust, have to overcome relational conflicts or to create commitment within the project team. Meeting in person conveys the necessary personal focus in these instances as it conveys all non-verbal cues. It provides the emotional status of the members, which was highly preferred in these situations. Secondly,

the current practice carries out meetings F2F to scope a task within a meeting, by mapping interdependencies and allocating tasks and responsibilities, and that creates a shared understanding. The same applies in the event of task conflicts, i.e. reaching an agreement by overcoming wide differences in opinion. Even though literature suggests that video conferencing could be used, empirical data suggests otherwise. Project members explained that the construction industry, with its unique work settings, complicates the coordination of the substantial amount of information. It is necessary to integrate diverse separate products, e.g. the objects underground need to fit the objects above ground, into a common product. Furthermore, the wishes of the client need to be represented by the developed product of the contracted party. In other words, there is a need for real-time interaction to coordinate all information under high time pressure. This was the reasoning to meet F2F in these instances. Leaner channels appeared to be unable to convey, and to coordinate, this amount of information. Lastly, both theory and practice suggest that audio conferencing should be applied for more routine communication interactions. In other words, highly task-focused decision making such as the progress meetings that were on work track level and where most uncertainties had already been clarified. Audio conferencing excludes visual cues and therefore decreases the number of distractions from the task at hand.

6. Discussion and implications for further research

This section compares the case study results, including the results of the validation session, with the existing literature on communication in teams, to demonstrate the support of the findings and the main differences. It must be reminded that the case studies took place in the Netherlands restricting the geographical disparity to this country and that influences the choice of channel. The explanation of the findings is subdivided into two sub-sections; situations where to use F2F communication, and the use of teleconferencing as a mean of communication. Furthermore, the use of the theoretical framework in the construction industry is evaluated. Lastly, limitations and implications for further research are discussed.

6.1 When to meet in person in group meetings

An important aspect of communication in project teams in the construction industry is to become a mature, well-developed, team. To have a successful project, there is a need to develop a relation constructed by the development of trust [25]. This research confirms that a project team should meet in person during meetings when it is necessary to develop their relationship. This is for example during a PSU meeting, the team has just been formed, or to create commitment for the project within a contract meeting. It appears that only F2F communication can establish the necessary level of social presence. This is due to the fact that F2F communication transmits all non-verbal cues such as body language and direction of gaze, whereas telecommunication does not [20]. Current literature, therefore, recommends for teams to invest in meeting F2F early in the project. This should result in better communication and greater project success [51], as confirmed by this research. Moreover, both research and theory insinuate that to maintain the interpersonal relationship, it is important to have periodical F2F contact with members that play an active role in the project. The cohesion of the team has an expiration date if not properly maintained. Meeting periodically in person fosters the relationship and increases the commitment to the project and its objectives [26,36]. However, if budget or time constraints make meeting in person infeasible, then it should be encouraged to use the next richest media channel, in this case, video conferencing. This to replicate F2F communication as close as possible [38]. The statement by Kupritz and Cowell [21], p. 55 summarizes the relational aspect; “People management is about interaction and conversation; technology should not de-humanize that interaction or you will drift away.”

Once a team is mature, or well-developed, the decision to either use teleconferencing or to meet in person depends on the determinants of the task at hand, i.e. the task complexity and the interdepartmental relationship. The decision to select a communication channel is interrelated to the balance between focusing on managing a task and actively working on a task. It is important not to oversimplify while managing tasks or to overcomplicate focusing on the actual production of the work [18]. Current practices suggest that teams should meet F2F to determine the scope within a meeting or to overcome task conflicts even though theory suggests that video conferencing could be used in these instances. Examples in practice are planning- and risk sessions where the initial schedule and risk dossier are developed. Another example is the more spontaneous meeting where the level of detail of a project between the client and the contracted party was negotiated. MRT and SPT hypothesize that video conferencing could be used to negotiate differing opinions into a common understanding as it conveys visual cues [19,39]. However, current practices claim that to create this shared understanding it is necessary to meet F2F. Only this channel can convey the message without creating a high risk of misunderstanding. A possible explanation for the difference between theory and practice in this research is the unique work settings of the construction industry. Project teams in the construction industry are made up of short-term partners, have a wide variety of functional expertise, have no prior experience of collaborating, and need to work together towards a collective complex goal. This makes it more complex to coordinate the information within a project [6]. On a project level, it means that there is a need for real-time interaction between the project members to coordinate the information under high time pressure. This appears to result in the necessity to meet F2F when the scope needs to be defined within a meeting or to overcome task conflicts, to integrate differing opinions into a shared understanding. Video conferencing

would oversimplify the meeting and would create the risk of missing interdependencies or parts of the scope. Concluding, to ensure consistency within these complex projects and avert the risk of misunderstandings that could possibly result in high losses [1] teams should meet in person in these instances.

6.2 Applicability of teleconferencing in group meetings

Overcomplication, i.e. using a too rich of a channel, leads to distractions from the task-focused subject and could result in overcommitment of time and money when traveling is required. This research confirms that audio conferencing should be used when there is a high focus on the task at hand, i.e. situations where uncertainties can be solved by integrating mostly factual data, to not overcomplicate the information processing. This is for example in meetings to discuss the proceedings on work track level when most uncertainties had already been clarified or to discuss specific uncertainties that could not be solved by e-mail. It is a prerequisite that a shared understanding has already been developed, and the team involved within the meeting can perform its separate function while still contributing to the shared objective [19]. Audio conferencing does not overcomplicate the processing of information as it does not convey visual cues while richer channels do. Visual cues are unnecessary in these situations, implying a distraction from the task-focused object [38].

This research provided an additional finding concerning intermediate levels, instead of just low and high, of the three determinants; task complexity, interdepartmental relationship, and team maturity. Examples in practice were; progress meetings to discuss the proceedings of a project, and more spontaneous meetings to clarify specific uncertainties. In these situations, the task is partly defined, i.e. the initial scope has been defined but more in-depth uncertainties remain that need to be discussed and resolved by exchanging both opinions and objective data. The wide variety in background and interdependency are already reduced with the attainment of a certain shared understanding as a result of the allocation of the main tasks and responsibilities. However, the more in-depth uncertainties remain, and tasks related to these uncertainties still need to be clarified and coordinated within the project team. Current practice proposes that video conferencing is the leanest communication channel to be used in these situations. Video conferencing was used in these situations without a high risk of misunderstanding, i.e. effective information processing. For example, the IPM team of the ECF in project A used video conferencing without communication errors for their recurring progress meetings to bring geographically dispersed team members together. The team members did have prior experience with video conferencing and were in possession of a video conference room. Also, video conferencing was used to solve task-focused uncertainties where it was necessary to exchange both factual data and opinions to come to an agreement. Audio conferencing appeared to be too lean for these situations. When members switched to audio conferencing, because of an unreliable video connection, it led to misunderstandings. Nevertheless, in most circumstances, the teams still met in person or even used audio conferencing. This can be explained by another finding of this research. The interviewees described other situational factors such as the availability of facilities, not comprehended by the theoretical framework of MRT and SPT, that influence the choice of a channel. These factors appear to be connected to a team member's subjective motivation to start considering teleconferencing over meeting in person. This motivation follows from a person's perception whether the advantages and disadvantages of teleconferencing outweigh those of F2F communication.

The team members in the projects explained that the most influential factors are geographic distance, and three inter-related categories that represent the organizational context; (1) culture, (2) technique, and (3) project team. This is validated by current literature on virtual project teams [8,34,52,53] and by the focus group within the research. The geographic distance is the foremost influential factor. This is related to the main advantage of teleconferencing over F2F communication; to be able to communicate without traveling regardless of the geographical disparity which could reduce personal stress [9,39]. Teleconferencing was used in multiple situations and made it possible to reduce the workload and personal stress as confirmed by literature [9]. Distance to overcome can be objectively measured [54], but also appears to be regulated by a team member's perception. This perception of distance was for example influenced by a person's workload. For example, one person saw a two-hour drive as manageable to overcome whereas another person considered this is as impractical due to their workload and therefore saw distance in general as a bigger barrier to overcome. This indicates the need to include distance in the choice of a communication channel based on objective distance and a person's subjective perception. This research sheds new light on the influence of geographical distance, as its not only an objective distance as currently described in the literature and should, therefore, be further researched.

The three inter-related categories of factors; (1) culture, (2) technique, and (3) the project team, represent the organizational context. This context encompasses both subjective and objective aspects of the work environment that are not fixed in time, and are therefore dynamic [21]. This research suggests that these dynamic aspects influence the choice of a communication channel and recent studies on virtual project teams indicate this as well. The culture, i.e. the attitudes and behavior of an organization, influences work patterns. This means that the attitude towards a certain communication channel is influenced by prior experience [52]. This research suggests that there is no embedded culture promoting the use of teleconferencing within the construction industry, which is an important condition for virtual teams to thrive [41]. Several team members mentioned that teleconferencing is seen as a last resort and not as a viable option next to meeting in person implying a negative motivation to use telecommunication. This is partly due to the aspect of technical failures, e.g. subpar connection or sound, and insufficient knowledge on the use of teleconferencing. In situations where the video

connection was subpar, members decided to either use audio conferencing, as it was more user-friendly and reliable, or to meet in person the next occasion. As pointed out by Poole and Zhang [24], technical errors in information distribution are understood as a failure of reliability and decrease the level of trust in a communication channel. To increase the trust in teleconferencing, and that promotes the culture of teleconferencing, technologies must be reliable and coherent for the entire project team [53]. The users should be able to work with the technologies and should, therefore, be sufficiently trained to communicate correctly through these means [33]. Furthermore, there should be a learning culture, i.e. knowledgeable team members should teach others. This could contribute to the tools becoming intuitive and normalized [8]. This includes the ability of a chairman to lead the meeting correctly while teleconferencing. The last situational category is the project team, how team members are involved in a meeting, e.g. project days and the use of an IPM team. Project teams used weekly collocated project days with the entire project team on which all formal meetings were planned. This negates the incentive to use teleconferencing, and that reduces the potential of teleconferencing. At one point, project teams could consider reducing the number of collocated days and to increase the use of video conferencing. These collocated days could also be only used to focus on the work of the task, excluding the F2F formal meetings. Furthermore, according to current literature, the most effective teams have up to nine members, especially communicating with teleconferencing. This is reflected by current practice as project members did not consider teleconferencing as a viable option when the size of the group was greater than around nine people. Also, in general, larger teams have trouble coordinating their information and communicate less [34]. The viability of teleconferencing would increase by organizing meetings with only up to nine members. Furthermore, it seems to be important to balance the members that join through video conferencing and those who are physically present. If there is a large deficiency, then some members might only listen instead of participating actively. When members are only listening, instead of being actively involved, is labeled as social loafing; the reduction of job performance when working with others in a group [55].

In conclusion, in order to utilize video conferencing within these progress meetings and more spontaneous meetings to clarify specific uncertainties, it is important to focus on the additional situational factors such as geographic distance and the size of a team. Once the conditions for these situational factors are met, then team members could become more motivated to consider teleconferencing as a viable option and use it for effective information processing. This is an additional finding of this research and is not represented by MRT or SPT.

6.3 The applicability of the theoretical framework in the construction industry

As shown by the previous subsection, the current framework constructed on MRT and SPT does not provide all aspects to determine the best fit of communication channel based on the situation at hand. Nevertheless, it has provided the fundamentals for this decision-making as hypothesized by Kupritz and Cowell [21]. This research shows that the message content, influenced by three determinants; the task complexity, the interdepartmental relationship, and the team maturity, should indeed fit the richness of a media channel. However, additional situational factors outside the framework of MRT and SPT influence the choice of a channel when teleconferencing can be used to transmit the information. In other words, the geographic distance that needs to be overcome and the situational factors originating from the organizational context; (1) culture, (2) technique, and (3) project team. The current literature on communication acknowledges this, criticizing MRT and SPT for their inability to include the organizational context [56,57]. However, as pointed out by Kupritz and Cowell [21], these arguments assume a fixed, stable organizational context which is not the case. This context changes over time, influencing the culture, the available techniques, and the project team. In conclusion, the use of MRT and SPT does still prove its value as the central tenets have been proven to be relevant in theory and in this research. These central tenets always apply and are therefore applicable to various situations. However, on the basis of the analysis of the results, it is recommended to keep the dynamic organizational context and the distance to overcome in hindsight as these factors do influence the choice of a channel. As these factors are not fixed in time it also implies that the alignment of a channel with a communication activity is a continuous iterative process, and what turns out to be a useful channel in one team may not necessarily be useful within another team [8].

6.4 Limitations and implications for further research

This research also has multiple limitations that need to be further explored, indicating the need for further research. The scope of the research limits the results and its findings. The project teams within the cases are located within the Netherlands. This limits the geographical disparity that influences the choice of a channel. As pointed out, one of the main advantages of teleconferencing is its ability to overcome geographical distance. Research in the future should explore cases with different geographical disparities and investigate to what extent this influences the considered choice. Also, the group meetings are focused on the aspects of planning- and risk management, excluding other types of meetings. The choice of a channel could be different for other types of meetings, although it is found that the fundamentals of the framework could hold for various meetings as established within the validation session. Nevertheless, there is no empirical material that can validate this statement. Further research should, therefore, acquire more empirical data on different types of meetings. Furthermore, the conducted research is short-term, neglecting long-term effects. To explore the long-term effects, it could prove to be valuable to conduct a long-term study. This could be done by putting the recommendations

of this research into practice by testing different communication strategies. The next main limitation is the lack of empirical data that shaped the framework and the current practice of this research. The current theoretical base of MRT and SPT and the cases did not provide the required information to fully compare the theoretical pattern with the pragmatic reality, which possibly led to faulty conclusions. This implies the need for similar studies to complement the theoretical base, and to validate the findings within this research. Lastly, building on the additional findings of this research, there is a need to further explore other situational factors, such as technique and geographic distance, that influence the choice of a communication channel. In other words, to study the dynamic work conditions that affect a person's motivation to use teleconferencing over meeting in person.

7. Conclusion and recommendations

This research was conducted to identify current practices on the use of teleconferencing and F2F communication during group meetings in multi-organizational teams. Furthermore, it was aimed to establish recommendations that organizations in the construction industry can apply to improve the use of teleconferencing as a complementary channel to or as replacement of F2F communication. This was researched as exploiting teleconferencing holds great promise because teams using telecommunication can maximize functional expertise by overcoming geographical disparity and reduce their travel time [8]. However, teleconferencing is currently ineffectively utilized within the construction industry due to a lack of knowledge resulting in ineffective communication [15]. The identification of current practice and possible recommendations are explored by establishing a framework, based on MRT and SPT literature. The fundamentals of the framework are to fit the message content, that needs to be transmitted, to the richness of a media channel. The more complex the message content, the richer the communication channel must be. This is used to study three civil engineering projects, with a focus on group meetings focused on risk- and planning management. These are analyzed by means of pattern matching to identify similarities and differences between theory and practice concerning the leanest possible communication channel to be used within a meeting. The findings from this research were used to establish recommendations and to validate the use of the theoretical framework in the construction industry. This was validated by experts who work in different disciplines of the civil engineering sector.

First, this study has provided the desired empirical material, that was currently lacking, about the use of different communication channels, specifically in multi-organizational project teams within the construction industry. The study adds to the knowledge to develop a communication strategy, effectively utilizing both teleconferencing and F2F communication within the construction industry. The findings of this research endorse current literature about the need to meet in person when project teams are developing their interpersonal relationship to become mature, well-developed teams. Only F2F communication appeared to be sufficient to establish the necessary level of social presence, and therefore the required emotional understanding of the situation. Both literature and this research, therefore, recommend for project teams to invest in meeting F2F early in the project to develop a level of trust that could ultimately result in better communication and greater project success. An example in practice is a Project Start-Up, where the entire project team comes together to get to know each other. Also, to maintain trust and to increase the commitment for the project, it is recommended to have periodical F2F contact with key players, such as the IPM figures. This study provided new insights on the choice of communication channel when it is necessary to create a shared understanding, in other words, to integrate varying opinions into a common perception. Current literature hypothesizes that it is possible to negotiate widely varying opinions into a common understanding with video conferencing. However, the project teams within this study met F2F in these instances, for example determining the scope of the planning within a meeting or to overcome a task conflict. Leaner media channels would have introduced a high risk of misunderstanding that was rather averted. A possible explanation for this difference between theory and practice is the unique work settings of the construction industry. It is necessary to integrate a high volume of specialized knowledge of short-term partners in combination with increasing demands for the complex present-day projects. This results in the need for more real-time interaction to ensure consistency and to avert the risk of misunderstanding that could possibly result in high losses. It is therefore recommended to meet in person to integrate widely varying opinions into a shared understanding. Nevertheless, if budget or time constraints make meeting F2F infeasible, then the next richest media channel should be applied as some form of communication is better than no communication.

Overcomplication of information processing leads to distractions from the task at hand and possibly overcommitment of time and money when traveling. F2F communication could have overcomplicated meetings where the project teams were already well-developed and had already established a shared understanding of the main scope of the task. This implies that teleconferencing is the leanest possible communication channel to use. Members defined these meetings as the action to go from the 80% to the 95% version of a task, i.e. fine-tuning. Audio conferencing was used within meetings that were highly task-focused. These are situations where the uncertainties could be solved by integrating mostly factual data. A practical example was the discussion of the proceedings on work track level when most uncertainties had already been clarified and the team was able to work independently. By reducing the number of cues within these meetings, by using audio conferencing, there were fewer distractions from the task at hand. This resulted in more efficient communication as hypothesized by literature. This study provided new insights on the use of teleconferencing in meetings in which the

initial scope has been defined but more in-depth uncertainties remain that need to be resolved by exchanging both opinions and objective data. There is a shared understanding due to the allocation of the main tasks, but the more in-depth uncertainties still need to be clarified and coordinated within the project team. In practice, these were recurring progress meetings to discuss the proceedings of the project, and more spontaneous meetings to clarify specific content related uncertainties. Current literature did not provide the background to determine which communication channel fits this situation, but this research did provide empirical material. Video conferencing was used in several instances without a high risk of misunderstanding, in other words, effective information processing, whereas audio conferencing was not sufficient. This indicates that video conferencing was the leanest channel to be used in these instances. Team members were able to have an emotional understanding of the situation and could convey their message to others. However, the project teams still used other channels than video conferencing in many instances. This is related to an additional finding within this research, not covered by MRT or SPT. This research provided a better understanding, not explicitly described by current literature, how a member's subjective motivation to use teleconferencing over F2F communication influences the choice of a communication channel. In practice, most project members considered teleconferencing as a last resort and not as a viable option. This influenced their decision-making in choosing a communication channel. For teleconferencing to be accepted as a viable option it is necessary to change people's subjective perception.

It was explained that geographic distance, and three inter-related categories representing the organizational context; (1) culture, (2) technique, and (3) the project team, are the most apparent factors that influence this subjective motivation outside the framework of MRT and SPT. The choice to either use teleconferencing or to meet in person depended heavily on the geographical disparity that existed between project members. Several members explained that some meetings would have been carried out with video conferencing instead of F2F if the distance between parties had been more substantial. Distance to overcome can be measured objectively but also appears to be regulated by a person's perception. One person might consider a two-hour drive as manageable to overcome whereas another does not due to e.g. workload or personal stress. The organizational context includes both subjective and objective aspects of the work environment that are dynamic, i.e. not fixed in time. This study suggests that the culture of a team and its individuals, the techniques used, and the specifics of the project team are the most apparent categories of situational factors influencing this general motivation. The findings indicate that there is currently no embedded culture in the construction industry promoting the use of teleconferencing. Several members were only used to meeting in person or by phone and not with video- or audio conferencing. This can be partly explained by technical failures such as a subpar connection or the lack of the necessary facilities when communicating with video conferencing. As a result, members switched to more normalized forms of communication such as meeting in person. It is therefore recommended, as validated by literature, to equip project teams with the right facilities to have a coherent system and to train project members on its use. This could contribute to the tools becoming intuitive and normalized. This includes suitable etiquette of communicating during teleconferencing because individuals are easier subjected to social loafing as compared to meeting F2F. The last situational category is the project team, how team members are involved in a meeting. Planning the formal meetings on weekly collocated project days negated the incentive to use teleconferencing and subsequently reduced its potential. It is therefore suggested to either use several collocated project days to only focus on the production of the task without formal meeting or to reduce the number of collocated days when deemed possible. Furthermore, the findings of the research suggest that it is a boundary condition for video conferencing to limit the number of individuals to nine as endorsed by literature. It is therefore urged to organize a meeting in a way that only up to nine members need to be involved to increase the viability of teleconferencing. These recommendations could improve the conditions for teleconferencing and therefore possibly contribute to the tools becoming more intuitive and normalized, and accepted as a viable option next to meeting in person. This could eventually contribute to improving the use of teleconferencing as a complementary channel to or as a replacement of F2F communication.

As for the relevance of the framework based on MRT and SPT in the construction industry, this study gives reason to believe that it can be used to fit the message content to a communication channel in this environment. The framework provides the fundamentals for this decision based on three determinants; the task complexity, the interdepartmental relationship, and team maturity. These central tenets have already proven to be valid in other environments and appear to be relevant in this industry. The framework provides the leanest possible communication channel to be used for specific situations, as validated within the research. However, when teleconferencing is the leanest communication channel to be used according to the framework, then it is important to include other situational factors that are not fixed in time. These are the geographic distance to overcome and the organizational context, represented by the categories of culture, technique and project team. Current literature has either focused on the specifics of the organizational context or on the use of MRT and SPT but not a combination of the two. This study has provided new insights on the possibility to use the MRT and SPT as the fundamentals and to include the organizational context for a more in-depth constructed choice of channel. However, this should still be further explored in future research.

This research has already established a certain awareness among the involved members of this research. Members became aware of the current underutilization and of the opportunities of using teleconferencing within their group meetings. A flowchart has been developed, depicted in Appendix C, that could be used during group meetings to extend this awareness

and to increase the practical value of this study. The flowchart provides a chairman of a meeting a decision-making tool to select the communication channel. The choices to be made are based on the determinants of MRT and SPT. Also, boundary conditions are provided about the use of a specific channel to comprise the organizational context. If these conditions are not met, then a different channel should be used, or the project team needs to make changes to their work environment. This decision-making tool could be further developed and still needs to be tested within the organizational environment. In conclusion, the alignment of the communication activity with a channel is still a continuous iterative process, but this research has provided materials to facilitate project teams in this process.

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Appendix A. Interview protocol

The current practice regarding the choice of communication channel based on the framework of the MRT and the SPT is mainly determined by collecting data through semi-structured interviews. The total number of people interviewed for the three projects was 18, six for each case. The main steps in each interview were: (1) the theoretical framework was explained to the interviewee to explain the context of the research and to scope the answers of the interviewee, and (2) the interviewee was questioned regarding the current use of the channels within the project and the possible changes that could be made to make the process more efficient and effective based on the situation at hand.

A.1. Step 1 – explanation of the theoretical framework to the interviewee

The theoretical framework is explained to the interviewee with the use of Table 4, describing the different determinants of the situation and the explanation of when a variable is low and high, and with Table 5, the choice of the leanest possible communication channel for each of the eight options. In other words, this is the explanation of the concepts of media richness, the message content, and the choice of communication channel depending on the situation at hand.

A.2. Step 2 – Questions regarding the current use of the channels within the project

After describing the theoretical framework, or in other words the theoretical pattern, the interviewees were questioned concerning the specifics of the meetings focused project control, the use of the different channels for each meeting including their reasoning, and questions regarding possible opportunities to utilize teleconferencing in such meetings. The general questions were as follows:

General questions

- What is your job description/ role within this project?
- When you need to define the result of the communication process with regard to planning- and risk management within this considered phase, how would you do this? Would you define it as inadequate, neutral, or as good?

Activity specific questions

Scheduling- and risk meetings

- What has been the general process regarding the scheduling- and risk meetings? What is the frequency of these meetings and who and how many people are involved? Furthermore, how is the communication established, in other words, which communication channel is used, including possibly other complementary tools?
- How are these sessions characterized in terms of the levels of the task complexity, interdepartmental relationship, and team maturity? In other words, what are the values (low or high) for the determinants? Does this change through time, and if so, what is the dependency?

After the determination of the values of the determinants for the specific sessions, there are some feedback questions concerning the use of the communication channels based on the situation at hand. The following questions are asked:

- What was the specific reasoning for choosing this communication channel in that situation and does this change through time?
- Which determinant; task complexity, interdepartmental relationship or team maturity, is the most influential?
- What are the pros and cons of using a specific communication channel?

After asking these questions, there is an intermission to determine if the theoretical pattern is correct and how this relates to the empirical pattern. If there is no match between the theoretical pattern and the empirical pattern it is asked why this is the case. This is followed up by questions specifically focused on the communication channels.

Questions focused on communication channels

- In which situation(s) are you sure that video conferencing or audio conferencing is no option, leaving only F2F communication?
- In which situation(s) are you (almost) sure that video conferencing is the best option for the situation at hand?
- In which situation(s) are you (almost) sure that audio conferencing is the best option for the situation at hand?

Concluding questions

The interview is concluded with concluding questions to determine if there are other factors that influence the choice of channel outside the theoretical framework, and what changes need to be made to utilize teleconferencing more within group meetings.

- What are according to you, possibly other factors that influence the choice of which communication channel to use, other than the determinants proposed within the theoretical framework?
- What are the main elements that need to be changed in current practice to increase the use of teleconferencing in group meetings focused on project control?
- Are there any other remarks or suggestions on the theoretical framework proposed in this interview?
- Are there any other remarks or suggestions that have not come up within this interview?

A.3. Validation of the information collected by the interviews

The interviews are transcribed to ensure that the collected data is objective. The transcribed data is then categorized based on a coding scheme to summarize the main findings. These summarized findings are then reported in a separate document for each interview that is sent to the interviewee for validation.

Appendix B. In case analysis

Table B.1: Pattern matching Project A

Message content **1. Task complexity** **2. Interdepartmental relationship** **3. Team maturity**	**Theoretical pattern(s) (Leanest possible channel and reasoning)**	**Empirical pattern(s)**	**Match**	**Explanation**
Option 1, 2, 3, and 4 (High maturity level) 1. Task: High or low 2. Departmental: High or low 3. Maturity: High	**F2F** F2F communication allows the team to overcome the relational conflict, effectively establishes group norms and trust, and/ or it can create commitment within the team and can establish cooperation with involved parties. F2F communication is recommended as the beforementioned aspects are accomplished largely through non-verbal cues and it makes it possible to have an emotional understanding of the situation.	**F2F** Teams communicate F2F when there is a high need for interpersonal skills, e.g. with critical tasks or time pressure, and to develop team cohesion. F2F interaction makes it possible to have the necessary emotional understanding of these situations.	+	The risk sessions to develop the risk dossier are a critical task in a project and are carried out F2F to create an open discussion. During a relational conflict regarding the contract between the parties involved the teams met F2F to convey the necessary personal focus. At the start of the project, the entire team met F2F to develop team cohesion with the goal to become a more mature team. The need for interpersonal skills was a boundary condition to meet F2F.
Option 5 1. Task: High 2. Departmental: High 3. Maturity: low	**Video conference** There is a need for visual cues when the opinions, following from a wide variety of RoF, of a group of people who are reciprocal interdependent must be negotiated. It excludes the use of audio conferencing. F2F interaction does remain the most ideal medium for small group discussions in case both the task complexity and interdepartmental relation are high.	**F2F** Teams communicate F2F when negotiating widely varying opinions, following from a high variance in RoF, into a common understanding while reciprocal interdependent, in combination with an ill-defined task. F2F interaction is preferred and is considered most effective when a task needs to be defined in a meeting and to ensure the integrality of a project.	-	The focus of the meeting to develop a schedule and the risk dossier is to define the scope of the project within the meeting and to define the interdependencies. This created a shared understanding and support for the project. This could only be done F2F and not with video as interdependencies can be overlooked and communication tends to be more closed. Meeting F2F makes it possible to reduce determinants, i.e. a shared understanding is created by discussing the varying opinions and mapping interdependencies.
Option 6 1. Task: Low 2. Departmental: High 3. Maturity: Low	**Video conference** When the task at hand is already well-defined and data collected is mostly of objective nature while there is still a high level of interdepartmental relation, i.e. decision making more focused on the task, the possibility to apply video conferencing becomes better substantiated. F2F communication is especially preferred for tasks that require a high level of coordination, i.e. high interdepartmental relation, in case the team does not have the knowledge to effectively use video conferencing.	**F2F** Teams meet F2F when a team is reciprocal interdependent in combination with a high variance of RoF, even though the task is already well-defined. Video conferencing would be too lean to transmit the amount of information, i.e. oversimplify. Tasks that require the need to create an unequivocal frame of reference while being interdependent, i.e. a necessity to coordinate a substantial amount of information, are highly preferred to be carried out F2F.	-	The team members preferred to carry out the re-evaluation of the in-depth schedule and the progress meeting where both parties were involved F2F. This followed from the variance between RoF and the level of interdependency. The task conflict was solved F2F as this type of communication is preferred to overcome differing perceptions.

Table B.1 (Continued) Pattern matching Project A

Message content **1. Task complexity** **2. Interdepartmental relationship** **3. Team maturity**	**Theoretical pattern(s) (Leanest possible channel and reasoning)**	**Empirical pattern(s)**	**Match**	**Explanation**
Option 7 1. Task: High 2. Departmental: Low 3. Maturity: Low	**Audio conference** When there are many ambiguous and unclear events, while the team can work independently and have already reached a shared understanding, it is not suggested to use a specific type of communication channel. Both F2F communication and teleconferencing could be applied. The choice of what communication channel to use in this case relies highly on the preference of the team and other situational factors.	The empirical data did not provide the information for this option.	N/A*	-
Option 8 1. Task: Low 2. Departmental: Low 3. Maturity: High	**Audio conference** When it is more routine communication interaction, i.e. common planning and task-focused decision making, then it is suggested to use audio conferencing to increase the focus on the task as it conveys fewer cues.	**Audio conference** Audio conferencing is used when the task at hand is highly task-focused to reduce the number of non-verbal cues.	+	In meetings where it was needed to only clarify specific task-focused uncertainties, the team used audio conferencing as it was the most user-friendly and was the least distracting media channel.
Option 9 - New 1. Task: Medium 2. Departmental: Medium 3. Maturity: Low	The theoretical data did not provide the information for this option.	**F2F or video conference** When a task is already more defined, most interdependencies are mapped, and the variance in RoF is medium then teams meet either F2F or with video conference. The choice of the specific channel is dependent on other situational factors such as geographical distance.	N/A*	Video conferencing was used for the progress meetings where only one party was involved, reducing the variance of RoF. Within progress meetings, tasks are already more defined, and there is already a certain shared understanding. The ECF team chose video conferencing because the members were geographically dispersed.
Option 10 - New 1. Task: Medium 2. Departmental: Low 3. Maturity: Low	The theoretical data did not provide the information for this option.	**Audio conference** Teams use audio conferencing to solve specific task-focused uncertainties where a combination of factual data and opinions is exchanged. Audio conferencing reduces the number of non-verbal cues resulting in less distraction.	N/A*	Within the progress meeting on work track level, when it was possible to work independently and with a low variety of RoF, but only a specific uncertainty needed to be resolved, the members included members on other locations with audio conferencing. Audio conferencing was chosen as it was user-friendly, and members were the least distracted from the task at hand.

*The empirical material for this data point is unavailable and is therefore not commented on in the analysis of results.

Table B.2 Pattern matching Project B

Message content **1. Task complexity** **2. Interdepartmental relationship** **3. Team maturity**	**Theoretical pattern(s) (Leanest possible channel and reasoning)**	**Empirical pattern(s)**	**Match**	**Explanation**
Option 1, 2, 3, and 4 (High maturity level) 1. Task: High or low 2. Departmental: High or low 3. Maturity: High	**F2F** F2F communication allows the team to overcome the relational conflict, effectively establishes group norms and trust, and/ or it can create commitment within the team and can establish cooperation with involved parties. F2F communication is recommended as the beforementioned aspects are accomplished largely through non-verbal cues and it makes it possible to have an emotional understanding of the situation.	**F2F or audio conference** During group meetings where the need for interpersonal skills is high, teams mostly meet F2F to create support for the project and to discuss critical matters. Audio conferencing is used to include members who are unavailable to meet F2F or video conference. This does make the meeting more difficult due to the lack of visual cues.	O	The progress meetings were critical conversations because of the high time pressure, which made it necessary to meet F2F as the tensions could only be overcome with all non-verbal cues. Within a risk session, it was important to think open-minded and discuss the impact of the risks. This was done F2F to have an open discussion and create commitment. Audio conferencing was used to include the top managers who were in transit (by car) excluding the possibility of F2F interaction or video conferencing. However, the conversation was more difficult as you were not able to see each other.
Option 5 1. Task: High 2. Departmental: High 3. Maturity: low	**Video conference** There is a need for visual cues when the opinions, following from a wide variety of RoF, of a group of people who are reciprocal interdependent must be negotiated. It excludes the use of audio conferencing. F2F interaction does remain the most ideal medium for small group discussions in case both the task complexity and interdepartmental relation are high.	**F2F** Teams meet F2F when a task is ill-defined, in combination with a high variance in RoF and reciprocal interdependency. Meeting in person makes it possible to create a shared understanding, to define the scope and the interdependencies within the meeting. F2F interaction is preferred when input is needed from every member within a team and subsequently coordinate all information into a common understanding.	-	The function of the development of an in-depth schedule was to make the implicit, explicit. The definition comes into existence, the interdependencies are mapped, and that creates a shared understanding. This is done F2F as teleconferencing cannot convey the amount of information coming from ten different people into one understanding.
Option 6 1. Task: Low 2. Departmental: High 3. Maturity: Low	**Video conference** When the task at hand is already well-defined and data collected is mostly of objective nature while there is still a high level of interdepartmental relation, i.e. decision making more focused on the task, the possibility to apply video conferencing becomes better substantiated. F2F communication is especially preferred for tasks that require a high level of coordination, i.e. high interdepartmental relation, in case the team does not have the knowledge to effectively use video conferencing.	**F2F** Group meetings with a high variation in RoF and high interdependency are carried out F2F to ensure the integrality of the project. F2F is used as it decreases the chance of a misconception. To create an unequivocal frame of reference, i.e. to integrate widely varying opinions while reciprocal interdependent, into a common understanding it is highly preferred to meet F2F.	-	The difference in RoF is an important aspect of the construction industry. The functional expertise of different disciplines must be integrated. This was favored to be done F2F, as there is a higher chance of misunderstanding with a leaner media channel. The case is a program, instead of a single project, increasing the level of interdependency. To coordinate the information, it was necessary to meet F2F to ensure consistency.

Table B.2 (Continued) Pattern matching Project B

Message content **1. Task complexity** **2. Interdepartmental relationship** **3. Team maturity**	**Theoretical pattern(s) (Leanest possible channel and reasoning)**	**Empirical pattern(s)**	**Match**	**Explanation**
Option 7 1. Task: High 2. Departmental: Low 3. Maturity: Low	**Audio conference** When there are many ambiguous and unclear events, while the team can work independently and have already reached a shared understanding, it is not suggested to use a specific type of communication channel. Both F2F communication and teleconferencing could be applied. The choice of what communication channel to use in this case relies highly on the preference of the team and other situational factors.	The empirical data did not provide the information for this option.	N/A*	-
Option 8 1. Task: Low 2. Departmental: Low 3. Maturity: High	**Audio conference** When it is more routine communication interaction, i.e. common planning and task-focused decision making, then it is suggested to use audio conferencing to increase the focus on the task as it conveys fewer cues.	The empirical data did not provide the information for this option.	N/A*	-
Option 9 - New 1. Task: Medium 2. Departmental: Medium 3. Maturity: Low	The theoretical data did not provide the information for this option.	**F2F or video conference** Meetings where the task was already partly defined in combination with a certain shared understanding, are carried out F2F or with video conferencing. The determinants are sufficiently reduced to use video conferencing without a high risk of misunderstanding.	N/A*	General progress meetings are either carried out F2F or with video conference (to include the geographically dispersed members). The progress meetings are mostly objective, and discussing deviations could be done with video.
Option 10 - New 1. Task: Medium 2. Departmental: Low 3. Maturity: Low	The theoretical data did not provide the information for this option.	**Video conference** The leanest communication channel to use when there is only a specific uncertainty, without variation in RoF and direct interdependency, is video conferencing.	N/A*	Once there is already a shared understanding and a certain definition then it is possible to use video conferencing, in other words, the fine-tuning or the 80% to 95% version. Video conferencing lends itself for meetings with a focus on the task, and where no direct coordination is needed.

*The empirical material for this data point is unavailable and is therefore not commented on in the analysis of results.

Table B.3 Pattern matching Project C

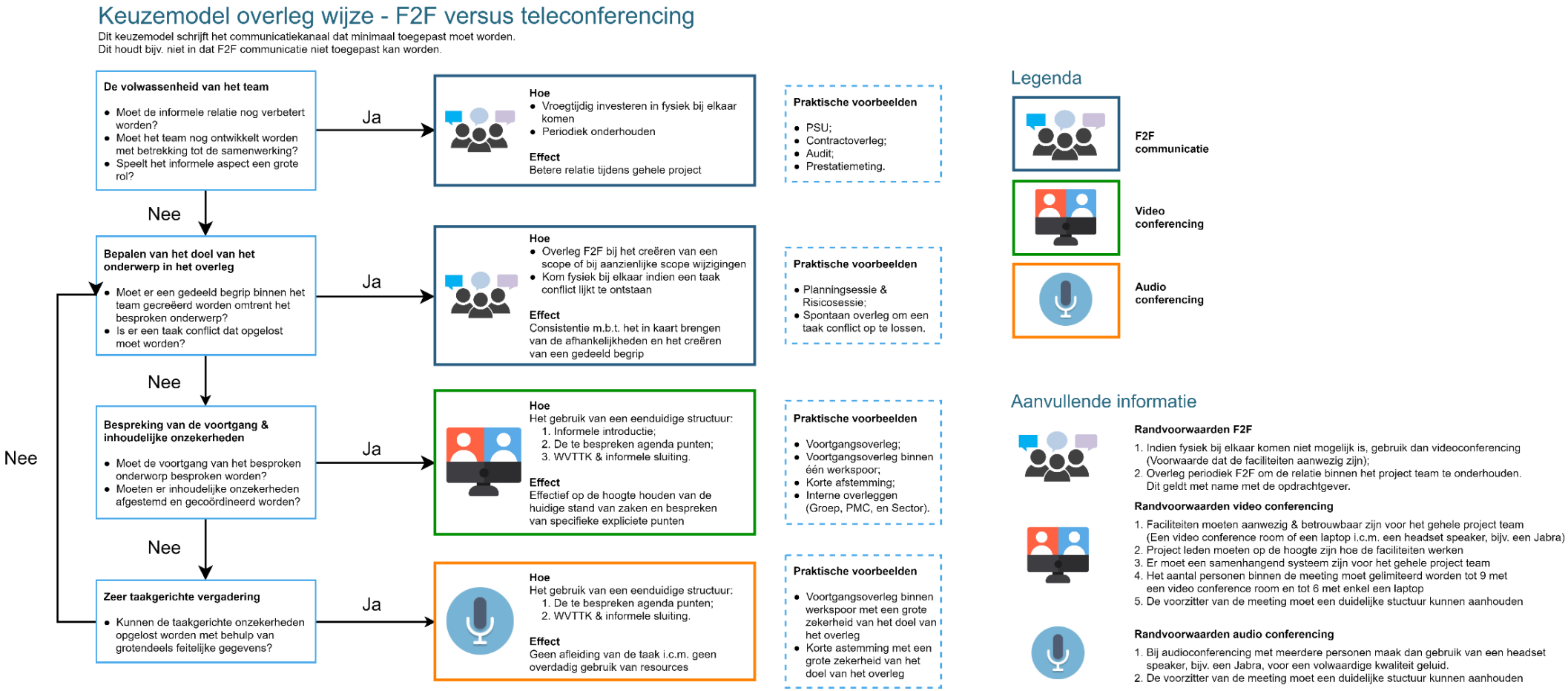
Message content **1. Task complexity** **2. Interdepartmental relationship** **3. Team maturity**	**Theoretical pattern(s) (Leanest possible channel and reasoning)**	**Empirical pattern(s)**	**Match**	**Explanation**
Option 1, 2, 3, and 4 (High maturity level) 1. Task: High or low 2. Departmental: High or low 3. Maturity: High	**F2F** F2F communication allows the team to overcome the relational conflict, effectively establishes group norms and trust, and/ or it can create commitment within the team and can establish cooperation with involved parties. F2F communication is recommended as the beforementioned aspects are accomplished largely through non-verbal cues and it makes it possible to have an emotional understanding of the situation.	**F2F** Teams meet F2F during meetings where there is a need for interpersonal skills or to develop the cohesion to become a mature, well-developed team. F2F communication allows members to communicate more openly and to express controversial topics.	+	The development of the risk dossier at the start of the project was done F2F to enhance the project teams' cohesion. A reason to get together F2F was to put someone in his place, in other words, to discuss a controversial subject. There was a need for interpersonal skills, best conveyed by F2F interaction. The two weekly progress meetings between the client and the main contracted party were done F2F to have open communication, to be transparent and to maintain their relationship as there were no collocated project days.
Option 5 1. Task: High 2. Departmental: High 3. Maturity: low	**Video conference** There is a need for visual cues when the opinions, following from a wide variety of RoF, of a group of people who are reciprocal interdependent must be negotiated. It excludes the use of audio conferencing. F2F interaction does remain the most ideal medium for small group discussions in case both the task complexity and interdepartmental relation are high.	**F2F** Teams meet F2F when the task is ill-defined, and the members are reciprocal interdependent in combination with a wide variance of RoF. F2F communication makes it possible to effectively define a definition and to determine the interdependencies within a meeting.	-	The administrative baseline schedule was developed F2F. The task was ill-defined, and the variating options were discussed. The interdependencies were made clear within the session. The team was mature as it was only with the client.
Option 6 1. Task: Low 2. Departmental: High 3. Maturity: Low	**Video conference** When the task at hand is already well-defined and data collected is mostly of objective nature while there is still a high level of interdepartmental relation, i.e. decision making more focused on the task, the possibility to apply video conferencing becomes better substantiated. F2F communication is especially preferred for tasks that require a high level of coordination, i.e. high interdepartmental relation, in case the team does not have the knowledge to effectively use video conferencing.	**F2F** Teams meet F2F in the event of a wide gap between perceptions of a situation in combination with a high level of interdependency. F2F communication makes it possible to have fast interaction when it is necessary to productively create a shared understanding.	-	The meeting where the main contracted party clarified the schedule towards the client was done F2F to bridge the gap of opinion regarding the duration of the schedule. The F2F interaction made it possible to create a shared understanding, which is more difficult with leaner media.

Table B.3 (Continued) Pattern matching Project C

Message content **1. Task complexity** **2. Interdepartmental relationship** **3. Team maturity**	**Theoretical pattern(s) (Leanest possible channel and reasoning)**	**Empirical pattern(s)**	**Match**	**Explanation**
Option 7 1. Task: High 2. Departmental: Low 3. Maturity: Low	**Audio conference** When there are many ambiguous and unclear events, while the team can work independently and have already reached a shared understanding, it is not suggested to use a specific type of communication channel. Both F2F communication and teleconferencing could be applied. The choice of what communication channel to use in this case relies highly on the preference of the team and other situational factors.	The empirical data did not provide the information for this option.	N/A*	-
Option 8 1. Task: Low 2. Departmental: Low 3. Maturity: High	**Audio conference** When it is more routine communication interaction, i.e. common planning and task-focused decision making, then it is suggested to use audio conferencing to increase the focus on the task as it conveys fewer cues.	**Audio conference** Project teams use audio conferencing when all determinants are low, i.e. task-focused decision making. Also, audio conferencing is mainly used as its capable of bridging geographical distance and it is a reliable technology.	+	Audio conferencing was used to overcome the geographical distance during short term technical spontaneous meetings. The main reason to specifically use audio conferencing was because of practical reasons. Audio conferencing was user-friendly and was always an available facility.
Option 9 - New 1. Task: Medium 2. Departmental: Medium 3. Maturity: Low	The theoretical data did not provide the information for this option.	**F2F** When both task complexity and interdepartmental relationship are a medium level, teams still meet F2F due to other situational factors outside the framework.	N/A*	The progress meetings with only the IPM members of the ECF were carried out F2F as the team was working collocated within the same office, making the use of teleconferencing redundant. The progress meetings between the client and the ECF at a later stage, the team was already well-developed, were still carried out F2F as the geographical disparity was manageable to overcome.
Option 10 - New 1. Task: Medium 2. Departmental: Low 3. Maturity: Low	The theoretical data did not provide the information for this option.	**F2F, video- or audio conference** Meetings in which only a specific uncertainty needs to be solved, by exchanging both opinions and factual data, are either done F2F, with video- or with audio conferencing. What channel is specifically used is dependent on other situational factors outside the theoretical framework.	N/A*	Video conferencing was used when team members needed to clarify an uncertainty that could not be solved by e-mail when team members were geographically dispersed. Video made it possible to convey opinions because of the visual cues. Similar meetings were carried out F2F when the geographical dispersion was manageable, or with audio in case the video connection was unreliable.

*The empirical material for this data point is unavailable and is therefore not commented on in the analysis of results.

Appendix C. Decision-making tool to select a communication channel within group meetings



Nederlandse samenvatting

Een onderwerp waarvoor grote belangstelling bestaat is virtualiteit in teams. Het communiceren binnen teams is over de laatste 30 jaar alsmaar meer uitgevoerd met behulp van technologische communicatiemiddelen zoals e-mail, telefonie en video conferencing. Teams die dergelijke communicatiemiddelen benutten kunnen functionele expertise maximaliseren door de geografische afstand te overbruggen. Deze trend is onlangs geadopteerd door de constructie industrie om ook hier de voordelen van teleconferencing te benutten. Echter, het gebruik van deze technologieën behaalt niet het beoogde resultaat. De achterliggende reden is dat de communicatiemiddelen niet op een juiste manier worden toegepast, mede doordat er geen rekening gehouden wordt met de unieke werk condities van de constructie industrie. Dit gebrek gaf aanleiding voor een onderzoek naar het beter toepassen van teleconferencing als aanvulling op of ter vervanging van Face-to-Face (F2F) communicatie binnen de constructie industrie, gericht op groepsoverleggen. Deze studie is uitgevoerd bij een ingenieursbureau in Nederland wat eenzelfde vraag reflecteert en waarmee ook de praktische waarde van deze studie is verantwoord.

Een theoretisch kader gebaseerd op de contingency theorie is ontwikkeld om weloverwogen een communicatiekanaal te kunnen selecteren. Daarnaast kan hiermee de benutting van teleconferencing in project teams bestudeerd worden. Deze theorie claimt dat de communicatie activiteit moet overeenkomen met het communicatie kanaal wat uiteindelijk tot een beter begrip leidt. Dit is verder geconceptualiseerd met Media Richness Theorie (MRT) en Social Presence Theorie (SPT), welke beide gevalideerd zijn als instrumenten om dit vorm te kunnen geven. De communicatie activiteit is opgesplitst in de twee hoofdaspecten van communiceren, met andere woorden de aspecten met betrekking tot de relatievorming en de details van de desbetreffende taak. De specifieke determinanten hierbij behorend zijn; taak complexiteit, interdepartementale relatie en team volwassenheid. Dit theoretisch kader is gebruikt om drie civiele-technische projecten in Nederland te bestuderen.

In de drie geselecteerde projecten, op basis van het beheersen van het aantal variabelen, is een combinatie van F2F communicatie en teleconferencing toegepast. Door deze projecten te analyseren op basis van het theoretisch kader, was het mogelijk om het verschil in gebruik van communicatie kanalen te baseren op de karakteristieken van de projecten. Deze analyse is uitgevoerd met behulp van de data verzamelt door de analyse van documenten, het uitvoeren van semigestructureerde interviews, en observaties van groepsoverleggen. Deze verzamelde data is vergeleken met het theoretisch kader met behulp van de 'pattern matching' methode, om de pragmatische realiteit te vergelijken met het voorgeschreven gebruik van communicatiekanalen volgens de literatuur. Op basis van pattern matching is een analyse uitgevoerd en zijn aanbevelingen geschreven welke vervolgens gevalideerd zijn met behulp van een controle groep. Deze studie voorziet de huidige literatuur van empirisch materiaal met betrekking tot het gebruik van verschillende communicatiekanalen, specifiek in multi-organisationele project teams in de constructie industrie, wat momenteel ontbreekt. Dit onderzoek onderschrijft de huidige literatuur om fysiek bij elkaar te komen wanneer een project team nog niet volwassen is, met andere woorden wanneer het nodig is om de team cohesie te verhogen, om relationele conflicten op te lossen, en projectleden te motiveren. Alleen F2F communicatie lijkt het nodige niveau van 'social presence' te kunnen bewerkstelligen. Daarnaast wordt het aangemoedigd om periodiek fysiek bij elkaar te komen om de relatie te onderhouden. Ook wordt het aangeraden om fysiek bij elkaar te komen in situaties dat de scope van het project in een overleg gedefinieerd moet worden of om een conflict met betrekking tot de taak op te lossen. De huidige literatuur beschrijft dat dit ook met video conferencing uitgevoerd kan worden, maar de huidige praktijk in de constructie industrie beweert van niet. Dit verschil komt voort uit de unieke werk condities van de constructie industrie, in praktijk de noodzaak voor real-time interactie en een hoge noodzaak voor integratie en het creëren van een gedeeld begrip. Alleen fysiek bij elkaar komen kan de integraliteit waarborgen en daarmee de onzekerheid voorkomen wat tot hoge risico's kan leiden binnen deze complexe hedendaagse projecten in de constructie industrie. Niettemin, indien het werkelijk niet mogelijk is om fysiek bij elkaar te komen, dan moet het volgende meest rijke media kanaal gebruikt worden.

Overleggen waarbij teams al volwassen zijn en waarbij al een gedeeld begrip gecreëerd is over de grote lijnen van de scope zijn uitgevoerd met teleconferencing zonder misverstanden. Deze overleggen worden omschreven als de actie om van de 80% naar een 95% versie te gaan, ook wel fine-tuning. Dit onderzoek onderschrijft de literatuur dat audio conferencing moet worden toegepast wanneer een meeting zeer gefocust is op de taak om daarmee zo min mogelijk afleiding van de taak te hebben. Dit was bijvoorbeeld een overleg met een specifiek werkspoor waarbij het doel van het overleg al duidelijk is. Verder heeft dit onderzoek nieuw inzicht verschaft met betrekking tot het gebruik van teleconferencing in meetings waarbij de drie determinanten gemiddeld zijn en niet alleen laag of hoog. Dit zijn bijvoorbeeld terugkerende voortgang overleggen. In andere woorden, een overleg waarbij de initiële scope al bepaald is, maar gedetailleerde vraagstukken moeten nog beantwoord en gecoördineerd worden. De praktijk reflecteert dat video conferencing het minst rijke kanaal is wat hier toegepast kan worden. Echter, een groot deel van deze bijeenkomsten worden alsnog fysiek of met audio conferencing uitgevoerd. De meerwaarde van dit onderzoek ten opzichte van de huidige literatuur is dat het andere situationele factoren inzichtelijk heeft gemaakt die de subjectieve perceptie van personen beïnvloedt. Deze subjectieve perceptie beïnvloed de motivatie om teleconferencing te gebruiken als communicatie kanaal. De huidige praktijk ziet het nu namelijk nog vaak als een laatste optie in plaats van een volwaardige optie naast F2F communicatie.

De analyse van de resultaten insinueert dat de volgende factoren het meest toonaangevend van invloed waren: de geografische afstand en drie intergerelateerde categorieën die de organisationele context representeren; (1) cultuur, (2) techniek, en (3) het project team. Projectleden gaven aan dat enkele overleggen met video conference was uitgevoerd in plaats van fysiek bij elkaar indien de te overbruggen afstand groter was geweest. Dit is wel afhankelijk van een persoon zijn perceptie, aangezien de ene persoon afstand een grotere barrière vindt dan een ander. De organisationele context omvat de dynamische aspecten van de werkomgeving waarin een project team zich bevindt. Op het moment is er geen ingebedde cultuur welke teleconferencing promoot, maar wordt er vastgehouden aan het welbekende gebruik van F2F communicatie. Dit gebrek aan cultuur komt gedeeltelijk door de technische gebreken, zoals een ondermaatse verbinding of afwezigheid van faciliteiten. Project teams kiezen in dat geval voor betrouwbare communicatie kanalen, in plaats van video conferencing. Daarom wordt het aangeraden om de nodige faciliteiten aan te schaffen om daarmee een samenhangend systeem te hebben in combinatie met training voor het gebruik. De laatste categorie, het project team, is de manier hoe personen in een meeting betrokken. Bijvoorbeeld projectdagen verminderen de toepasbaarheid van teleconferencing, omdat de formele overleggen op deze dagen ingepland worden. Het wordt daarom aanbevolen om deze formele overleggen op een ander moment in te plannen of het aantal projectdagen te limiteren. Daarnaast stelt dit onderzoek voor om het aantal personen in meetings met video conferencing te limiteren tot negen, aangezien de literatuur bevestigd heeft dat meer personen tot minder effectieve communicatie leidt. Deze aanbevelingen kunnen mogelijk bijdragen tot het institutionaliseren en normaliseren van teleconferencing.

De bevindingen van dit onderzoek bevestigen dat het theoretisch kader gebaseerd op de MRT en de SPT de basis biedt om een gesubstantieerde keuze te maken voor een communicatiekanaal. Echter, wanneer teleconferencing het minst rijke communicatie kanaal is wat toegepast kan worden, dan wordt het belangrijker om de organisationele context erbij te betrekken. In andere woorden de situationele factoren die de subjectieve perceptie van personen beïnvloedt. Deze studie biedt nieuw inzicht op het gebruik van MRT en SPT als de basis in combinatie met de te overbruggen afstand en de organisationele context voor een mogelijk meer gedetailleerde onderbouwing van de selectie van een communicatie kanaal.

De praktische waarde is gedeeltelijk het onderzoek zelf, door het tot stand brengen van het bewustzijn bij projectleden dat teleconferencing op het moment nog onvoldoende toegepast wordt. Er wordt nog niet voldoende gebruik gemaakt van het potentieel. Om deze reden is een flowchart ontwikkelt, te vinden in bijlage C, welke gebruikt kan worden als een keuzemodel voor het selecteren van een communicatie kanaal. De keuzes omvatten de determinanten van het theoretisch kader en randvoorwaarden waar de situationele factoren aan moeten voldoen om een specifiek kanaal te gebruiken. De conclusie van dit onderzoek is dat het afstemmen van een communicatie activiteit met een kanaal een iteratief proces blijft, maar dat de uitkomsten van dit onderzoek project teams wel kan ondersteunen bij het maken van deze keuze.