Summary

Research Objective

The objective of this research was to gain more knowledge on the influences on performance in and of multi-organization, multi-team (MOMT) projects: How can the many teams perform well separately (team performance) and in collaboration (project performance)? Due to increasing complexity in new product development (NPD) these projects are increasingly formed to have access to the distributed specialized expertise required for solving the numerous diverse complex design tasks. However, many MOMT projects still fail.

So far, not much research has been done on these projects. In recent years, there have been studies either on multi-team projects within a single organization (e.g., Hoegl et al., 2004; Hoegl and Weinkauf, 2005; Kazanjian et al., 2000; Sosa et al., 2004) or on a single multi-organization team (e.g., Majchrzak et al., 2000; Malhotra et al., 2001). There are a few case studies on multi-organization, multi-team projects (e.g., Argyres, 1999; O’Sullivan, 2003).

To make a contribution to NPD literature, in this research several relevant variables with an (in)direct influence on team and project performance are identified and studied. Unlike most other studies applying a global performance measure, here performance is measured by two dimensions representing the typical challenges of NPD projects – i.e., meeting product specifications and requirements (effectiveness) and being on time and within budget (efficiency) – to reveal differential relationships.

Research has shown that communication has an influence on performance (e.g., Allen, 1977; Dougherty, 1992; Kratzer, 2001). In MOMT projects team members and teams need to communicate to solve complex new design problems. This problem-solving communication is crucial to exchange and combine diverse knowledge to find high-quality solutions, and to have the information required timely available to anticipate and quickly react to possible changes in the NPD process. These influences on effectiveness and efficiency are studied in the first research question: What is the influence of problem-solving communication on team and project performance in MOMT projects?

With a systematic design approach the complexity inherent to the problem-solving process can be reduced by structuring and facilitating the communication (Leenders et al., 2007), investigated in the second research question: What is the influence of a systematic design approach on problem-solving communication within and between teams in MOMT projects? When team members work in a systematic way they can handle the task complexity (Pahl and Beitz, 1992) as they communicate accordingly, which then contributes to team performance and the overall project success.
Summary

These two research questions are studied on two levels of analysis, namely the local, team level (intrateam and extrateam and team performance) and the global, project level (interteam and project performance). Whether there are different effects between these levels is studied in the third research question: Is there a difference in the studied relations between the local and global level of MOMT projects?

Methodology

On the local level hypotheses are stated and quantitatively tested, while on the global level a mainly qualitative case study is done as only two MOMT projects are studied – both in the field of space research. These projects were selected because they are theoretically useful for studying the influences in complex NPD projects: A complex new product is developed in a collaboration of many teams with members from different organizations in an uncertain environment under high time and budget restrictions and high quality requirements.

In these projects quantitative as well as qualitative data was collected in 2005 – i.e., questionnaires from team members and leaders of 48 teams (response rate 45.7 percent) and interviews with team leaders. Since only teams with at least two respondents are analyzed, the final sample consists of 40 teams with a response rate of 49.3 percent. Additionally, in 2007 four project managers were interviewed: in each project one of the higher-level management and one of the middle management.

On the local level team performance (effectiveness and efficiency) is central. As stated above, team effectiveness is measured by one item – the quality: whether the product specifications and requirements are met – whereas team efficiency is measured by two items referring to the adherence to the planned schedule and to planned budget. The reliability of the latter measure was tested by using Cronbach’s alpha. Because it was above .70, the integrity of the construct is good (Nunnally, 1978). Additionally, running a factor analysis, these two components of team effectiveness and efficiency were extracted. Hence, they can be studied separately.

Team performance is studied to be dependent on the communication among the members of the team (intrateam) and with the other teams of the MOMT project (extrateam) (cf. Hoegl et al., 2004; Hoegl and Weinkauf, 2005; Keller, 1994; Souder and Moenaert, 1992). Since there is no single best way to communicate and no way of communicating is equally successful, several communication variables need to be studied. It is expected that their influences differ for the team performance dimensions studied. Based on the information-processing theory, hypotheses on the influences of relevant intrateam and extrateam problem-solving communication variables on team effectiveness and on team efficiency in MOMT projects are stated.
Because of the high complexity in the NPD process there is a high degree of uncertainty, which can be reduced by intense communication (Galbraith, 1973) – joint problem solving and decision making – but also requires effective leadership functions (Bell and Kozlowski, 2002; Tushman, 1979). In this research, intense workflow in the non-routine problem-solving process refers to how often it needs to be communicated (frequency) to have (timely) access to the required information for joint problem solving, and how the new design problems are creatively solved in interaction (task disagreement). Effective leadership functions refer to the coordination of the problem-solving process versus the involvement in that process – representing different team leader roles in MOMT projects. Besides the classical role of team leaders as ‘managers’ who only coordinate the problem-solving process among their team members (‘process promotor’), ‘chief engineers’, who are fully involved in that process contributing their specialized expertise (‘technology promotor’), are also important.

Intrateam communication is studied by all three variables – the frequency, team leader role, and task disagreement – whereas extrateam communication is only studied by the frequency because the main problem-solving activity should take place within the teams – a reason for a multi-team approach.

These communication variables are hypothesized to be dependent on a systematic approach. There are different systematic design principles that structure and facilitate the problem-solving communication. Hierarchical task decomposition, systematic variation (creative re-combination of existing solutions), and satisficing (selecting a satisfying solution after a moderate length of time) are defined as relevant principles of a systematic design approach in MOMT projects (cf. Leenders et al., 2007). Decomposing the task hierarchically – thereby defining the degree of task interdependence – reduces the communication need especially between teams, while systematic variation and satisficing facilitate the problem-solving process within teams.

For testing the hypotheses, questionnaire data is used. The reliability of this data was tested using the within-group inter-rater reliability (IRR: James et al., 1984) to see whether the respondents of one team rated similarly (IRR >.70). For network data (communication frequency and degree of task interdependence) the reciprocity or mutuality was analyzed, to see whether team members or teams report the same value of the relation they have with each other (Wasserman and Faust, 1990). Additionally, for a more in depth analysis, the qualitative data from team members is applied complementarily.

On the global level, the influence of the communication between all teams (interteam) of the MOMT project on project performance is studied (cf. Chiu, 2002; O’Sullivan, 2003; Sosa et al., 2004). As with the extrateam communication, here only the communication frequency and its dependence on the degree of task interdependence, defined by task decomposition, are studied.
Summary
These relationships are analyzed for two points of measurement (2005 and 2007) to be able to draw more reliable preliminary conclusions. Using data from both a manager of the higher and of the middle management level allows for different perspectives on the project as a whole. Additionally, for the first point of measurement, data from questionnaires and team leader interviews was available. This triangulation (i.e., usage of multiple sources of information and methods) helps to support the research findings – improving the validity and reliability of the research (Yin, 1989) – and to have an as complete picture as possible – capturing the contextual complexity (Benbasat et al., 1987).

The results found on this global level are compared against the ones of the communication between teams on the local level (extrateam) – as explanatory and dependent variable – to find out whether there are similar influences.

Results
The hypotheses on local-level relations are tested running multiple regression. Each hypothesis is tested separately, relaxing the significance level to 10 percent, because of the small sample size.

Due to the resource-consuming nature of exchanging and processing information, a generally more negative influence of problem-solving communication on team efficiency than on team effectiveness is expected and also found – but only for within teams. Very frequent intrateam communication has a negative influence on team efficiency. Up to a certain degree this also applies to the degree of task disagreement. But a very high degree – many discussions in the problem-solving process – has a positive influence as high-quality solutions can be found, which are likely to require no or less time- and budget-consuming rework. When team members and the leader satisfice in the solution-selection process, then there is less task disagreement among them since the solutions are selected based on product specification and organizational issues (time and budget).

Looking at the team leader role in the intrateam problem-solving process, both the teams led by a manager as well as the teams led by a chief engineer are more effective than teams led by a leader with a hybrid role. The manager facilitates the process of problem solving according to product specifications and requirements, while the chief engineer contributes his specialized knowledge. The team leader acts more like a manager when there is a lower degree of task interdependence among the team members in order to facilitate the information flow among them. They have to jointly solve the assigned design tasks of the team because their complementary knowledge is the reason they were appointed to the team. The team leader promotes the problem-solving process when solutions are mainly creatively found or created by systematic variation of existing solutions. But when these two techniques are applied together, the team leader acts as a chief
engineer contributing his expertise for jointly intuitively and systematically finding new solutions.

Between teams, very frequent communication has a more negative influence on team performance than the intrateam communication: there is a linear negative influence on both the team effectiveness and efficiency. The more teams communicate with other teams, the lower their performance. This need of frequent extrateam communication is influenced by the degree of task interdependence a team has with the other teams in the MOMT project.

In a case study it is tested whether the influences found for the extrateam relations and team performance also appear to be present on the global level. As with team performance, project performance is also measured by effectiveness and efficiency. The negative influence of frequent communication between teams on performance is expected to be found only after the moderate communication frequency is exceeded. This indicates an inversely u-shaped relation with effectiveness and efficiency, which however could not be tested with only two cases.

A moderate interteam communication frequency is important for a project to be effective. In this interaction appropriate assemblies of the different teams' sub-solutions are found in order to meet the specifications and requirements of the overall product. But this problem-solving communication should not be too frequent because then teams can be overtaken by other teams' requirements.

For project efficiency even a bit more frequent communication is expected to be positive. Important information on, for instance, potential changes can be transferred faster to the different teams that might be affected, which reduces the risk of doing resource-consuming redesign. Again, very frequent interteam communication will be negative – here because of information overload.

The positive influence of the degree of task interdependence between teams on their communication frequency is also found on the global level. The higher the degree of task interdependence among all teams, the higher the interteam communication frequency. But decomposing MOMT projects into different (sub-)subsystems leads to segmentation of that interteam communication, with the highest communication frequency within the (sub-)subsystem rather than between them. It has been found that the degree of task interdependence, and hence communication frequency, is the highest within teams, followed by between teams of the same (sub-)subsystem, and then between (sub-)subsystems.

Comparing the two levels of analysis, there are different mechanisms. Also on the local level itself differences were found between the intrateam and extrateam relations. This means relationships found on one level cannot be easily translated to another one. That which applies to teams does not necessarily need to be valid for the entire project.
Implications

Based on the results to answer the three research questions, it was possible to achieve the research objective: to gain more knowledge on the influences on the performance in and of MOMT projects – the successful team and project performance. Theoretical as well practical implications can be drawn.

For theory, it is shown that a moderate communication frequency within teams is crucial for team performance and between teams for the performance of a MOMT project. Such inversely u-shaped influences were also found in recent NPD studies (e.g., Leenders et al., 2003, 2007; Patrashkova et al., 2003; Patrashkova and McComb, 2004). Contrary to information-processing theory, with increasing complexity – thus, increasing information-processing need to reduce inherent uncertainty – communication frequency should not increase linearly in order to perform well.

Within and between teams there are distinct influences of the communication variables on effectiveness and efficiency, highlighting the differential information-processing requirements to be effective versus to be efficient. Therefore information-processing theory needs to be supplemented by a contingency approach. Since performance dimensions are often different from another, performance should not be studied as an overall performance variable as this may hide relationships between independent variables and the separate performance dimensions (Keller, 1994).

Comparing the local and global level – intrateam and extrateam and team performance vs. interteam and project performance –, there are different mechanisms. For instance, while frequent communication between teams is negative for team performance, up to a certain degree it is expected to be positive for project performance. Because communication can be structured and facilitated by a systematic design approach, there is an indirect influence of systematic design principles on performance – as theoretically discussed by Leenders and colleagues (2007). With information-processing theory, relations for one level cannot be deduced from another level. They need to be studied individually in order to reveal the level-specific mechanisms.

Due to the different influences of the local and global level, the practical implications need to be discussed for the respective level separately.

Within teams very low and very high degree of task disagreement has a positive influence on team performance. Depending on the nature of task, satisficing – which negatively influences task disagreement – should be applied to a very low or very high degree: i.e., for more routine vs. non-routine tasks. Team leader acting as manager or chief engineer, have a positive influence on team effectiveness, whereas neither being full manager nor full chief engineer leads to
less effectiveness. Thus, there should be a best balance of both team leader roles, which, for example, can be achieved by two persons leading a team.

For a team to perform well, the communication with other teams needs to be reduced by structuring the project accordingly that teams do not have many task interdependencies with other teams, but mainly with the ones within the same (sub-)subsystem. There should be a moderate communication frequency between the teams of different (sub-)subsystems because they need to develop the complex new product in collaboration that the MOMT project can perform well.

This study contributes to close the gap in literature on performance of complex NPD projects. In this research it is shown that, although systematic design principles can be applied to handle complexity, complex NPD and MOMT projects cannot be made simple. They represent complex systems with many interactions that need to be successfully managed.