

# Shared knowledge in complex teams

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# Valorization

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## **Economic relevance**

The present dissertation has economic relevance as it contributes to improve teamwork and communication in teams by helping team members to develop a shared mental model. This is an important contribution to modern economy as teamwork and a shared understanding of the task among team members is increasingly crucial to accomplish complex tasks in many work settings. For example, in aviation there are often few opportunities for team members to share information that not directly pertains to the tasks but that may still help these team members to understand each other's behaviour. This specifically applies when team members work at different locations and communicate via text-based messages, such as datalink. These teams need (organizational) support to exchange relevant information, develop a common picture of the situation and work smoothly toward a common goal. The findings from this dissertation suggest ways to support teams in this process and provides practical recommendations for active and guided knowledge sharing. Chapters 4 and 5 give detailed descriptions on the design of such active and guided knowledge sharing in different circumstances. These chapters demonstrate how knowledge sharing can result in more accurate and more similar knowledge structures thereby contributing to efficient teamwork.

This dissertation is also relevant to economy as organizations and practitioners can use it as a guideline on how to identify team members' shared mental models in dynamic environments. This is important as shared mental models are cognitive constructs that first need to be elicited, analysed and interpreted. Chapters 2 and 3 outline how a cognitive task analysis and card sorting tasks allow to get insights into the mental knowledge structures of individuals and to operationalize the similarity of these knowledge structures between team members. Specifically, these chapters describe how to conduct a cognitive task analysis and a card sorting task in air traffic controllers and list the general advantages and disadvantages of both methods.

In general, improving shared mental models and teamwork among team members can have more far-reaching economic and social relevance. For instance, effective teamwork between air traffic controllers and cockpit crews can positively affect safety in aviation, while inefficient teamwork potentially leads to incidents and accidents in air traffic. Thus, through helping team members to work together more efficiently through operational measures or enhanced training we may be able to further increase safety. In addition, improving teamwork through facilitating shared mental model development may positively affect efficiency. For example, smooth cooperation among air traffic control, airlines and airport operations can lead to more environmentally friendly traffic flow and more service-oriented management of passengers. The results of the present studies can guide the design and

implementation of training for these purposes in aviation and other complex work settings such as health care.

Improving safety and efficiency in aviation becomes particularly interesting in the future in which the European Union foresees the harmonization of the European airspace<sup>9</sup>. To achieve this harmonization, all European parties will need to engage in collaborative decision making and advanced automation will help them in this process. Team members with an effective shared mental model will more easily come to collaborative and safe decisions. In addition, if automation fails, they will still be able to work together effectively despite the changed situation.

### **Target group**

A number of the insights in this dissertation are particularly valuable for the target group of air traffic controllers. The previous paragraphs describe a number of examples of how the different studies contribute to understand and improve shared knowledge and teamwork in the profession of air traffic control. Chapters 2 and 3 specifically address the content and similarity of mental models of air traffic controllers.

The subsequent chapters apply to complex teams in general. Complex teams also work in the military (e.g. combat teams), in health care (e.g. surgery teams), in the transportation and (nuclear) power industry (e.g. control room teams). They have a number of characteristics in common that make a shared mental model particular relevant for efficient teamwork. Complex teams must process and share large amounts of new information in a restricted time period to make decisions collaboratively and adapt quickly to changing and maybe unforeseen situations. In such situations, complex teams have limited possibilities to communicate explicitly while mistakes often have major consequences. Complex teams overcome these situations and perform the required tasks because they benefit from a shared mental model, which allows them to anticipate each other's behaviour and maintain a similar picture of the evolving situation.

### **Activities and products**

A tangible product that evolves from the present research activities is the tool *TeamTris*. *TeamTris* is a dynamic environment in which multiple team members interact in a cooperative game world. It is easy to learn but hard to master, which intrinsically motivates the user. *TeamTris* was used in the experiments in this dissertation to study teamwork, shared mental model development, team adaptation and communication. In addition, the tool can easily be adapted to investigate other study variables (e.g. mental effort) in multiple experimental conditions, as well as to support training and selection of professionals.

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<sup>9</sup> More information on the harmonization of the European airspace is available at the project site of the Single European Sky ATM Research: <http://www.sesarju.eu/>

As a selection tool, *TeamTris* could be applied to test qualifications for specific professions such as air traffic control. While this assumption needs to be validated, there is some indication for the usefulness of *TeamTris* during selection procedures. During a small pilot study parallel to this research, air traffic control trainees played *TeamTris*. It appeared that they were able to learn and play the game quicker than the average team of university students. The air traffic control trainees reached a high performance score within a short amount of time and avoided penalty points successfully. This small study implied that *TeamTris* may distinguish individuals that have been selected on specific competences (e.g. planning, decision making, teaming) and individuals that have not been selected on these competences.

*TeamTris* could also be applied during training of professionals. First, *TeamTris* can be applied to address team aspects much earlier during training of operational tasks than it is currently common. Due to the complexity of these operational tasks (e.g. air traffic control) trainees often first have to train individual skills before they learn to work effectively in a team. Since *TeamTris* is a simulated and abstract game environment, young trainees can discover and train the importance of a shared understanding and effective coordination before they are an expert on the actual task. This may help them later when they train on the workflow together with their senior colleagues.

A second useful training application of *TeamTris* is to further improve teamwork abilities of experts and to help them to adapt to (non-nominal) situations. Through *TeamTris* team members of an inefficient team can for example train communication skills, time management (i.e. when to provide information to each other) and smooth coordination in a safe environment. They can experience the impact of inefficient teamwork without fatal consequences and can train to change their behaviour and improve their skills. In addition, *TeamTris* allows individuals to train in unexpected situations such as a system failure. Although such situations are unusual it is extremely important that complex teams manage these situations adequately. Through *TeamTris* they can develop strategies of how to build a shared mental picture of the evolving situation, make plans how to adapt to the situation and jointly execute this plan.