FOI-R--1507--SE
November 2004
ISSN 1650-1942
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- A field study of breathing apparatus firefighters' communication during rescue operations

Command and Control Systems
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SWEDISH DEFENCE RESEARCH AGENCY

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Issuing organization	Report number, ISRN	Report type
FOI – Swedish Defence Research Agency Command and Control Systems P.O. Box 1165 SE-581 11 Linköping	FOI-R--1507--SE	Methodology report
	Research area code 8 Human Systems	
	Month year November 2004	**Project no.** E7096
	Sub area code 81 Human Factors and Physiology	
	Sub area code 2	

Author/s (editor/s)	Project manager
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	Sponsoring agency
	Scientifically and technically responsible Peter Berggren

Report title

Communication and Team Performance in BA Teams - A field study of breathing apparatus firefighters' communication during rescue operations

Abstract (not more than 200 words)

The lack of guiding principles for the communication during breathing apparatus rescue operations is seen as a problem by many firefighters. There is a wish to obtain further heuristics for the communication, but there is no agreement concerning what successful communication is and how it should be achieved. This research aimed through field studies to see how the BA firefighters and the BA leader communicate with each other. It also aimed to investigate if some answers to what defines 'good communication' during BA rescue operations could be found. Through a qualitative analysis of the communication patterns of two pairs of BA firefighters the impact on the communication made by common ground establishment, team knowledge and similar phenomena, such as experience of working together, has been investigated. The results illustrate communicative problems which can occur during a rescue operation and shed light on the gravity of an agreement on what information should be mediated by the BA firefighters. It is also seen how experience of working together can be suggested to help the firefighters to communicate efficiently.

Keywords

communication, team performance, common ground, team knowledge, firefighting, naturalistic decision making

Further bibliographic information	Language English
ISSN 1650-1942	**Pages** 80 p.
	Price acc. to pricelist

Utgivare Totalförsvarets Forskningsinstitut - FOI Ledningssystem Box 1165 581 11 Linköping	**Rapportnummer, ISRN** FOI-R--1507--SE	**Klassificering** Metodrapport
	Forskningsområde 8. Människa och teknik	
	Månad, år November 2004	**Projektnummer** E7096
	Delområde 81 MSI med fysiologi	
	Delområde 2	

Författare/redaktör Ida Lindgren Peter Berggren Hans Jander Richard Hirsch	**Projektledare** Martin Castor
	Godkänd av Erland Svensson
	Uppdragsgivare/kundbeteckning
	Tekniskt och/eller vetenskapligt ansvarig Peter Berggren

Rapportens titel (i översättning)

Kommunikation och prestation i rökdykarteam - en fältstudie av rökdykares kommunikation under insats

Sammanfattning (högst 200 ord)

Bristen på riktlinjer gällande radiokommunikationen under rökdykarinsatser ses som ett problem av många brandmän idag. Det finns en önskan att formulera tumregler som kan hjälpa rökdykarna, men det finns ingen konsensus angående vad "bra kommunikation" är eller hur den ska uppnås. Denna studie syftade till att genom en fältstudie studera hur rökdykare och rökdykarledare kommunicerar under insats och att försöka ge ett svar på vad som definierar "bra kommunikation" i denna domän. Genom en kvalitativ analys av kommunikationsmönster från två par av rökdykare har studien undersökt hur 'common ground'-etablering, 'team knowledge' och erfarenhet av att arbeta tillsammans påverkar kommunikationen. Resultaten visar vilka kommunikativa problem som kan uppstå under rökdykarinsatser och belyser vikten av ett samförstånd vad gäller vilken typ av information som ska förmedlas och när. Resultaten visar även hur erfarenhet av att arbeta tillsammans starkt kan underlätta rökdykarnas arbete

Nyckelord

kommunikation, prestation, team, mentala modeller, common ground, rökdykning, naturalistiskt beslutsfattande

Övriga bibliografiska uppgifter	**Språk** Engelska
ISSN 1650-1942	**Antal sidor:** 80 s.
Distribution enligt missiv	**Pris: Enligt prislista**

ACKNOWLEDGEMENTS

First and foremost we want to thank the wonderful firemen in the Community of Stockholm and at Ågesta Övningsanläggning - this project would not have been possible without your help and participation!

We are also grateful to the people at Skövde Räddningsskola, for giving us insight into the education of BA firefighters, and the participating firemen in Linköping for introducing us to the BA firefighting domain and for helping with the equipment.

TABLE OF CONTENTS

ABBREVIATIONS AND GLOSSARY

BA	breathing apparatus
BA firefighter	fireman working with a breathing apparatus.
BA leader	fireman in command of the BA firefighters.
mul	mean utterance length

BA (breathing apparatus)	andningsapparat, luftpaket
BA firefighter	rökdykare
BA pair	rökdykarpar
BA leader	rökdykarledare
BA team	rökdykargrupp, rökdykare + rökdykarledare
Incident Commander	Räddningsledare
Reference room	referensrum
Reference point	referenspunkt
Base point	baspunkt
Reinforced base point	förstärkt baspunkt

1 THEORETICAL BACKGROUND

In many fire fighting districts today, there are no specific rules or guidelines regarding the communication between the firefighters and the leader during BA rescue operations. The lack of guidelines has started to come up for discussion more and more frequently and amongst many firemen there is a wish to obtain heuristics for how to structure the communication, but the opinions about how it should be done and if it is necessary differ. This project aimed at studying the communication between BA firefighters and the BA leader to see how they communicate with each other during rescue operations. The study has especially investigated what kind of information the firefighters mediate to each other and if there are differences between utterances mediated through the communication set and through the mask (face-to-face). The project is a master's thesis in cognitive science made in cooperation with the Department of Man-System-Interaction at the Swedish Defense Research Agency (FOI) in Linköping, and the Department of Language and Culture, ISK, at Linköping University. The thesis was made possible through consultation from firefighters at the Fire Department in Stockholm, *Stockholms Brandförsvar*.

1.1 General introduction to the domain

According to *Arbetarskyddsstyrelsens Författningssamling* (AFS), 1995:1 2§, BA rescue can be defined as entering dense fire smoke, usually indoors, with the purpose of saving lives, fighting fire or other similar activities.

BA rescue is a dangerous business. The heat is often intense and at the same time a very physically demanding job has to be performed. Therefore it is of great importance that the firemen are completely healthy, physically strong and stress tolerant in difficult situations. It is also important that the firefighters know themselves and their physical limitations to be able to save their strength and cooperate with their colleagues. On top of the health risks there are many external risks which can be difficult to predict. Since vision is often reduced and sometimes totally nonexistent, there is an enhanced risk for the firefighters to fall down or in other ways hurt themselves. Due to the fire and smoke, there is also a risk of explosions or falling objects from over head. Since plastic has become a usual material in most of our houses, the smoke has become more harmful. The plastic materials make the smoke intensity greater and cause the smoke to contain several toxic gases and substances. Due to the fact that the smoke additionally contains carbon monoxide, an enhanced risk for lack of oxygen exists. (AFS, 1995:1)
The equipment used by the firefighters during this kind of mission is a breathing apparatus with compressed air, a communication set, fire-helmet, -suit, -gloves, -boots and belt. The BA leader should have an air hose for rescue, a safety line and a bag containing an extra mask, a small whiteboard, pen and paper. It is usual that the BA firefighters carry tools with them, such as an axe, a crowbar, a lamp or similar equipment. Altogether, the equipment weighs about 25 kilos. Additionally, the hose weighs about 1,5 kg per meter.

1.1.1 The organization and search methods during BA rescue

The smallest unit during BA rescues consists of an Incident Commander (*Räddningsledare)*, a Pump Operator, a BA Leader and two BA firefighters. There are different ways of organizing the BA firefighters and the leader during a rescue operation. The organization mainly concerns the role of the leader and there seems to be two styles that dominate. In one style, which is implemented in Linköping, the BA leader has a very active role and can be seen as a

third BA firefighter. He wears his mask, breathing apparatus, during the whole rescue operation and is always ready to enter the object to help his colleagues, if needed (Fogel et al., 2004). This style is also taught at Skövde Rescue School (Ignell, 2004). The other style, which is used in Stockholm (where the current study was performed), is called *BA rescue with reinforced base point* (*rökdykning med förstärkt baspunkt*). This means that the leader works as a center of the rescue; he organizes the firefighters and instead of always being ready to enter himself, he has an extra pair (or more) of firefighters that can be used in the rescue if needed. In both ways of working, the BA leader must have experience of BA rescues and his task is to maintain a secure connection between himself and the BA firefighters and supply information which he considers necessary for the firefighters. He should also check the time and order the firefighters to retreat when the time is right or if it is needed for some other reason. (AFS, 1995:1)

The first thing the BA firefighters do when entering the building is to establish a *reference room*. This is usually the first room they enter and it is established as a reference room when the entire room has been searched and both firemen agree on its structure. The aim with establishing a reference room is to create a room in which the firefighters feel familiar and fairly safe and from where they can start their search. The search tactic is then to search the room behind the first door in the reference room, then the room behind the second door and so on. A distinction between *search* and *close search* is made. A *search* is when the BA firefighters search the room together and try to find out what kind of room it is (kitchen, office, bathroom etc.), how it is situated in relation to other rooms, and see if there are patients or important objects to save, et cetera. A *close search* is when one firefighter alone searches around the spot on which he is standing (about one arm's length). If he, for example, finds a doorway he can feel with his hands or feet on the floor on the other side of the door, in the adjacent room, and see if he can find a patient lying there or characteristic objects which can give him a clue as to what kind of room it is. (Rytterlund, 2004)

During the rescue it is important that both BA firefighters report *points of reference* to each other. Points of reference are objects they find on their way that can help create a picture of how the building looks. The objects should preferably be fixed objects, for example doors, couches, stoves or beds. Smaller objects, for example chairs, can easily be moved around by the hose as the firemen search the room and are considered to be bad points of reference. The points of reference are not only used to characterize the room but are also an important help when it comes to orientation. (AFS, 1995:1)

The BA firefighters must regularly check the pressure in their breathing apparatus and should start their retreat in good time before the bottles of air are empty (the air in the bottles lasts for about 20-30 minutes during hard work). As soon as one of the firefighters considers it time to retreat he must report this to his colleague and the leader and the retreat then starts immediately. During the search it is also important that both firefighters at all times try to maintain a secure retreat route, make sure that there is a connection to the BA leader (if the communication is hindered the rescue should be aborted immediately), and maintain contact with each other. As soon as one of the BA firefighters considers the situation dangerous, feels insecure, or disoriented, the rescue should be aborted. (AFS, 1995:1)

During larger BA rescue operations there are often several pairs of BA firefighters working, simultaneously or one after the other. When a pair of BA firefighters for some reason retreat and if the search is not finished, the pair should hand over their information about their search and the building to the next pair of firefighters. This handover, relief action, can be made in

many different ways and one common strategy is that the handover takes place outside the building, that is, the first pair exits the building and reports to the BA leader and the next pair before the entrance of the new pair. Another strategy is to let the two pairs meet on the inside. This can be very effective if the relief action is conducted in a smooth way, but can also be rather problematic since four firemen then have to share the same communication set frequency. There does not seem to be a clearly defined way of conducting the relief action, but rather the individuals working, the situation and the circumstances decide how the relief action is performed.

A BA firefighter/leader must participate in at least four exercises every year; two cold and two warm. To be regarded as warm, the temperature during the exercise must be at least 50°C. In the Community of Stockholm, the cold exercises can be made in the fire-fighting districts whereas the warm ones are made at Ågesta training center.

1.1.2 Communication

During the search and rescue, the BA firefighters must maintain constant contact with each other. This can be done through body contact or through holding the hose between them. Despite the sounds of the fire and the thick protection they wear it is possible for the firefighters to communicate without using the communication set. When they are close to each other it is usual that the firefighters communicate by screaming to each other, but this leaves out the BA leader. For the BA leader to be able to secure the firefighters' safety during the BA rescue operations, it is of great importance that he keeps track of where the BA firefighters are and what they are doing. The leader is also meant to function as the external eyes of the BA firefighters, looking at the properties of the smoke, changes of the fire, et cetera, and to supply this information to the firefighters if the information is considered important. Since the BA leader is separated from the firefighters, the only way he can know what is happening on the inside is through the communication set. The firefighters have to tell him about their actions, their capacity, the construction of the building and so on. The importance of functioning communication between the BA leader and firefighters can therefore not be overestimated. (Fogel et al., 2004).

There is a federal legislation concerning how a BA firefighter should be and what he should do (mainly through the AFS 1995:1), but much is decided on a municipal level. This means that even though the stations are fundamentally similar, there are some differences in work methods. One part of the BA rescue work which is not governed by any rules is communication. There seems to be one general heuristic for how the communication is supposed to be during rescue: the BA firefighters speak and the leader listens (Fogel et al. 2004; Ignell, 2004). How much should be said and what the firefighters should inform the leader and each other about is not as clear. At Skövde Rescue School, the firefighters are taught to inform the leader as soon as a change takes place in the building; the air is hotter/colder, more/less smoke, a patient/important object is found, the entrance of a new room, and similar events (Ignell).

Figure 1. The mask and communication set button

To be able to talk through the communication set, a button on the front of the mask has to be pushed (see the round button directly underneath the glass in the middle of the mask in Figure 1). Due to the very physically demanding situation the BA firefighters are in and the fact that the firefighters often have their hands full (with tools or the hose), pressing the radio button to speak to the BA leader can sometimes feel too time consuming and strenuous. It is therefore considered important that the firefighters themselves get to choose when to talk. If they are asked questions from the leader, this might interrupt their work. But if the firefighters are not mediating the information the leader is interested in, he does not have much of a choice other than to ask. Too many questions from the BA leader can therefore be seen as a failure in the firefighters' communication (Fogel et al., 2004; Ignell 2004).

The lack of guiding principles for the communication is seen as a problem by many fire-fighters, especially amongst firefighters on a higher level. There is a wish to obtain further heuristics for the communication, but there is no agreement concerning what successful communication is and how it should be reached. There have been discussions about both the content and amount of communication. Concerning the content of the communication it has been suggested to postulate a nomenclature, inspired by the military, which would constrain the communication and make it similar for everyone within the field. This suggestion has been both welcomed and dismissed (the opponents seem to consider it too constraining). In the Community of Stockholm, some effort has been made to try to find specific terms that all firemen can use. So far, only one is in use; *life-rescue* (*livräddning påbörjas*). This term is to be used as soon as a patient is found and it should preferably be repeated, so that everyone in the team hears that the goal for the operation has been changed. This way the paramedics can be prepared on the outside when the patient comes out. Regarding the amount of communication there seems to be two general approaches. One says that the BA firefighters should speak as much as they can; this way they are inclined to say something important at some point. The risk with this way of communicating is that the BA leader might not be able to differentiate between the important and unimportant utterances if he is under a lot of pressure. The other approach says that the BA firefighters should speak as little as possible and only mediate information which is important and interesting. A problem with this approach is that it requires that everyone knows what important information is, which does not seem to be the case (Rytterlund, 2004).

1.2 Analyzing communication in the BA firefighter domain

Firefighting is a classical example of a natural decision-making setting. The situation in which the firefighters work is very dynamic and hard to predict; the fire and smoke changes quickly, new goals for the team can be defined any minute, everything the team does influences the situation, et cetera. The quick changes of goals, the sometimes poorly defined procedures and the time pressure create situations where decisions have to be made quickly. The decisions do not only have to be fast, but also right; a poor decision might cause death of a patient or firefighter.

Naturalistic decision-making in the firefighting domain has been studied by several researchers (e.g Fogel et al., 2004; Klein, 1999; McLennan, Omodei, Holgate, & Wearing, 2003; McLennan, Pavlou, & Omodei, 2004). In these studies, the influence on performance made by mental simulation, intuition, earlier experiences and similar phenomenon have been under the looking glass, whereas communication and coordination have been somewhat neglected. Through studying how psychological processes can be related to better versus poorer decision making, McLennan et al. (2003, 2004) have especially studied the quality of decisions made by firemen depending on experience.

The BA firefighters make fast decisions continuously through their work; which search tactics to use, how to put out the fire, how long they should stay, which way to take out a patient, et cetera. The communication can also be said to be a subject for very important decisions. Since a button has to be pushed in order for the BA firefighter to talk via the communication set, a decision has to be made not just regarding the content of the utterance but also if it is relevant enough to mediate to everyone in the team or just to the partner. The pushing of the button does not only mean that the receivers of the message differ, but also that the firefighter is hindered from doing things simultaneously (he can for example not use the hose and talk via the communication set at the same time since using the hose requires that he holds it with both hands). These are decisions made on a rather unconscious level, based on training and experience, but should not be underestimated – these decisions influence everyone in the team.

1.2.1 Language as action

When two people are involved in conversation their words are not just words, they are actions. With the lexical choices we make, the direction in which the rest of the conversation will go can be altered, we can display what is on our minds, we can make other people do things for us, and much more. We do not just speak because we like the sound of our voices, we speak to get things done (we *do* things with words). According to Clark (1996), language can be seen as joint actions, where the people involved are acting together. Language is more than just a speaker who speaks and a listener who listens, both parts co-ordinate their actions and the roles change – the speaker can easily become the listener, and vice versa.

Common ground

Our choices of words and actions are to a great extent based on what Clark (1996) calls *common ground*. According to Clark, "Everything we do is rooted in information we have about our surroundings, activities, perceptions, emotions, plans, interests. Everything we do jointly with others is rooted in this information, but only in that part we think they share with us. … Two people's common ground is, in effect, the sum of their mutual, common, or joint knowledge, beliefs, and suppositions" (pp. 92-93). This means that whenever we are involved

with other people, we try to estimate what knowledge we have in common, and based on this shared knowledge, our common ground, we shape our actions.

Common ground is needed for us to be able to coordinate our actions with each other and can be found both on a communal and personal level. Ways of inferring what people know, believe or assume is usually by categorizing them by community. Communal common ground means that we assume to have knowledge based on that we belong to communities, e.g. nationality, gender or profession. One person can be part of several different communities and every community can be said to have a special lexicon. Clark (1996) stated that "The information we infer from membership in a community isn't all or none but *graded*, and what is remarkable is how accurate we are in this grading" (p. 110).

Common ground can also exist on a personal level, the best example being friends. Much of our common ground is based on joint perceptual experiences and joint actions with other people. A friend knows you better than an acquaintance and an intimate friend knows you even better. Friends have experienced many things together and might even have developed their own personal lexicon. By personal lexicon it is not meant that they have developed an entirely new language, but that they have their own words, for example nicknames and slang.

When we interact with other people, we have an intuitive feeling for what we do and don't know, even if we cannot recall a piece of information at the moment. This intuition is also concerned with what other people know, and is strongly egocentrically biased: we are more likely to believe that others possess a piece of information if we know it ourselves. This egocentric view can sometimes lead to discrepancies in common ground and lead to a *false consensus effect*, which refers to situations where two people believe that they believe the same thing, when, in fact, they do not (Clark, 1996). The false consensus effect can be compared to the different types of pseudo-agreements discussed by Hirsch (1997). Discrepancies in common ground can lead to pseudo-agreement/disagreement:

> *Pseudo-agreement* (verbal agreement but real disagreement) : Two persons hold a formulation to be true and are unaware of the fact that for them the formulation expresses two different cognitive contents.
> *Pseudo-disagreement* (verbal disagreement but real agreement): Two persons are unaware of the fact that for them two different formulations actually express the same cognitive content and it is the case that one of the formulations is held to be true while the other formulation is held to be false. (pp. 64-65)

Clark (1996) points out that "Common ground is not just ready to be exploited. We have to establish it with each person we interact with." (p. 116). Our common ground affects the words we choose to say, but it is also built by our lexical choices. Common ground can be said to be a kind of foundation for our communication, and at the same time our communication helps in building our common ground. This feature of common ground makes it very easy to end up in a circular discussion (what came first, common ground or communication), but according to Clark this seems to be a bigger problem than it actually is; we start building up information about others since childhood (see Clark for further discussion).

1.2.2 Institutional talk

How does this knowledge about each other influence our communication? When involved in conversation with other people, our way of talking is decided by several different factors such

as culture, age, roles in the group or other social restrictions, context, et cetera. According to Duranti (1997), several researchers have, for example, shown how strongly our culture affects the lexical choices we make and the organization of turn-taking.

People also carry with them assumptions about how conversation should be carried out, which can be viewed as some kind of heuristics; we assume that the person we talk to is telling the truth (unless he or she shows obvious signs of irony, sarcasm, or is in other ways signaling that the content is not true), we also assume a balance in turn-taking, and it has been shown that there exist rather explicit rules for how speakers and listeners should behave (e.g. the length of pauses and eye-gaze) (Clark, 1996).

When the actors involved in talking are situated in an *institutional* interaction, what comes out of their mouths is even more restricted than during ordinary conversation. According to Drew and Heritage (1992) "… the institutionality of an interaction is not determined by its setting. Rather interaction is institutional insofar as participants' institutional or professional identities are somehow made relevant to the work activities in which they are engaged" (p. 3). This means that an institutional interaction takes place when people interact, not as themselves personally, but as professionals. A good example of this is communication in the courtroom, where the lawyer is not speaking for himself personally but as a formal character representing another person.

Recently there has been much research into institutional settings and it has been shown that there are three features that usually exist in institutional interaction (Drew & Heritage, 1992):

1. There is an *orientation towards some goal, task or identity* (or all) that is conventionally associated with the institution in question. Institutional interaction between a doctor and a patient is oriented towards reaching a diagnosis and does, for example, not involve small-talk about the weather.
2. Communication in institutional interaction may often be *characterized by special and particular constraints* on what is an allowable contribution. An example is the courtroom, where the participants' contributions to the interaction are strictly constrained by their roles.
3. Institutional talk can often be associated with *inferential frameworks and procedures* that are particular to the specific institutional context. An example of this can be when professionals, e.g. doctors, withhold responses that in ordinary conversation might be considered required (e.g. sympathy or agreement).

With the features above in mind it is easily seen that the communication between the BA firefighters and their leader can be categorized as institutional. Their communication aims at reaching a specific goal; saving a patient, putting out fire, et cetera. There are also many constraints on the communication, foremost because of the use of the communication set but also because of the need of short and concise utterances. Moreover, the communication clearly shows signs of procedures specific to BA fire fighting; when involved in a BA operation, the firefighters only talk about the ongoing mission, using some words and sentences which are specific to the domain and avoid unnecessary utterances.

In institutional settings, the interaction is often unequal. This means that there often is an inequality in the participants' power and an imbalance in turn-taking. This is also reflected in the use of courtesy. In ordinary conversation, courtesy is a common way of "packaging" requests and similar utterances, making our conversation "nicer" and "friendlier". In

institutional talk there is often no space for the everyday courtesy, leaving the language appearing rather blunt. But even so, it has been shown that people tolerate impoliteness in institutional talk, whereas it is seen with unfriendly eyes in ordinary conversation (Drew & Heritage, 1992). These two features are clearly seen in the BA firefighters' communication, where the firefighters choose when they want to talk and how much, whereas the BA leader is supposed to be quiet and only ask questions or supply the firefighters with information when it is absolutely necessary. There is also no time for polite wrappings of requests; they are short and straight to the point. (Fogel et al., 2004).

1.2.3 Categorizing communication

Within pragmatics and several other linguistics fields it has long been common to try to categorize people's language use. This has influenced researchers within numerous other areas, such as the human factors field. The last ten years, manifold studies investigating communication and its influence on team performance has been conducted. In many of these studies, categories have been used as a tool to study communication (e.g. Commarford, Kring, & Singer, 2001; Rasker, Post, & Schraagen, 2000).

Through categorizing language, general structures and trends can easily be visualized in a comprehensible way, which might help to create guidelines for preferred communication. But there are also weaknesses in this method. One of the difficulties with categorization of language utterances is to create categories that capture what the researcher is really looking for. There is a risk that the categories are either too exclusive (specific) or too inclusive (general). It is especially difficult to categorize communication in everyday contexts. In the fire-fighting domain, categorization of the communication can be considered suitable due to the fact that the BA firefighters' communication is relatively constrained and specific.

1.3 Team knowledge

Team knowledge is thought to relate directly to team performance and is considered to be knowledge that is shared across the members of the team. According to Cannon-Bowers, Salas and Converse (1993) team knowledge affects the teamwork on two levels. First, it enables the members of the team to anticipate other team members' behavioral and informational requirements when communication channels are limited. Second, team knowledge of the task at hand creates a common frame of reference from which the team members can act.

Team knowledge and shared mental models can be said to be two different names for the same phenomenon and despite the differences in names, several researchers (Blickensderfer, Cannon-Bowers, Salas & Baker, 2000; Cannon-Bowers et al., 1993) tend to agree that team knowledge seems to help teams coordinate their work in a smooth and efficient manner. According to Blickensderfer et al. (2000), many researchers have found evidence that suggests a positive relationship between the degree of team knowledge and team performance.

1.3.1 Pretask team knowledge and dynamic team knowledge

A discrepancy between pretask team knowledge and dynamic team knowledge can be made. According to Blickensderfer et al. (2000), pretask team knowledge is knowledge belonging to long-term memory which the team members "carry with them into task performance" (p.433). "The extent to which team members come to the task with compatible knowledge and mental models we consider their level of pretask team knowledge." (p. 433).

Dynamic team knowledge is knowledge that develops when the team is actually performing their task. Blickensderfer et al. (2000) state that "Dynamic understanding is the degree to which teammates develop compatible assessments of cues and patterns in the situation, the implications of these for the team and task, how the team is proceeding, and particular actions that certain members need to take" (p.435). During performance, team members carry with them their pretask knowledge and with the help of that knowledge, and the actions taken by other members of the team, they interpret patterns and cues in the environment. The degree to which consistent interpretations amongst the team members can be made on the fly is crucial for the performance of the team.

Blickensderfer et al. (2000) present suggestions of different ways to analyze different parts of pretask team knowledge. Through dividing it into several elements it is easier to show which kinds of knowledge that help to create pretask team knowledge. (see Blickensderfer et al., for more details and analysis methods). For a team to possess a high degree of pretask team knowledge its members need to have knowledge about the following:

- *The task objectives and goals of the team.*
  Team members' possession of compatible knowledge of the overall goals of the mission and the team may help team performance.

- *Task performance, sequences and timing.*
  It is important that the team members know the procedures associated with different roles and that they have appropriate knowledge about the equipment and possible relations among equipment.

- *Team members' roles, responsibilities and characteristics.*
  It is not only knowledge of the characteristics of the mission that is important; knowledge of the team's members may also be vital for successful teamwork. Pretask team knowledge of roles and responsibilities can help make sure that each team member understands the interdependencies essential to the team. It also helps teammates to understand how to help each other and, in turn, to help the team. An understanding of each others' characteristics makes it possible for the members of the team to predict the needs and future behavior of other members.

- *Acceptable teamwork behaviors.*
  To be able to work and communicate efficiently, it helps if everyone on the team is in agreement with what constitutes acceptable behaviors in the group.

In a study conducted by Fogel et al. (2004) at the fire-fighting station in Linköping, it was found that the firefighters and their organization fulfilled the requirements for pretask team knowledge proposed by Blickensderfer et al. (2000) to a great extent. Through defining the goal of the operation before the firefighters entered the object, they made sure that everyone on the team was working towards the same goal. If the goal was suddenly changed, it was not only changed for the BA team but for the whole team at once. Regarding the performance and equipment, it was considered important that everyone in the team knew each other's roles and this was made sure through shifting tasks regularly (if a person was a BA leader last time he worked, he might be a BA firefighter the next time). This way of organizing the work helped the team members to understand the specific tasks associated with the different roles and also helped everyone on the team to improve and maintain their knowledge of the equipment. The

composition of the team (13 men in the same shift) and the fact that they always worked together resulted in that the men knew each other very well, both as professionals and on a personal level. The firefighters participating in the study reported that they knew both their colleagues' positive and negative characteristics and they thought that the knowledge of each other helped them in their work. They especially commented on that knowing each other well helped their communication during BA firefighting; they could often hear how their colleagues felt (how tired they were) from the tone of their voice or choices of words. Finally, there seemed to be a team work 'culture' at the station which was passed on from one generation to the next. There were seldom new recruits employed which made it easy for the experienced firefighters to 'bring up' the new employees to become good team members.

1.4 The importance of functioning communication

In situations where people work together in teams, communication is often the way through which the members make things happen and co-ordinate their work. According to MacMillan, Entin and Serfaty (2002) efficient communication is the foundation for effective team cognition and performance. But it is difficult to define what efficient communication is. MacMillan et al. (2002) suggest that "efficiency can be achieved through multiple paths, including use of organisational structure that reduces communication workload as well as the introduction of activities such as collaborative pre-mission planning that may reduce the need for communication or make communication more efficient by increasing mutual awareness and shared mental models"(p. 411).

For team members who are separated in space but still need to have a shared mental model of the situation, such as the BA team, functioning communication is vital in order for the team to build and maintain shared awareness of the situation and of each other (MacMillan et al., 2002). For a BA team to be successful, the two BA firefighters on the inside need to be able to "draw the picture" for the BA leader on the outside, making it possible for him to build his own mental model of what the interior looks like, what the firefighters are doing, and what will happen next. Since the BA leader is separated from the firefighters there is no other way for them to transfer this information than through communication.

If the firemen had unlimited time to solve their missions they would have time to fully coordinate their actions and perform better. But a fire has its own life and does not allow extended discussions on the firemen's behalf, turning rescue operations into a race against the clock. It is therefore important to keep the contributions to the communication short and straight to the point. MacMillan et al. (2002) state that "Communication requires both time and cognitive resources, and, to the extent that communication can be made less necessary or more efficient, team performance can benefit as a result" (p. 408).

Hutchins, Hocevar and Kemple (1999) have summarized cognitive behaviors characteristic of high performing teams found in different studies within the team work area. The characteristics are overlapping and very similar to the notion of team knowledge (Blickensderfer et al., 2000), but stress the importance of functioning communication in a more salient way. According to Hutchins et al., it is important that the members of a team are familiar with how they are supposed to speak, using homogeneous and conventional speech patterns and that little negotiation of what to do and when to do it should be required. This type of knowledge is often tacit, that is, somewhat unconscious and hard to articulate.

1.5 Questions to be answered

Based on the information presented above a couple of assumptions about the BA team's communication can be suggested. It is clear that the amount of communication affects the performance of the team, where too little or too much communication can be suggested to affect the performance in a negative way. The Swedish proverb "*lagom är bäst*" suits this situation very well. In relation to this it can also be assumed that the content of the communication is more important than the amount. Additionally, opinions about what constitutes 'good communication' differ amongst the firemen and it can therefore be said that the definition of good quality communication and the wished quantity of communication within the BA team varies between individuals.

With the assumptions above in mind and with an explorative approach, the current research aimed at investigating the following questions:

- What in the communication is influencing the performance?
- What is most crucial; the amount or the content of the communication? What is preferred, much or little communication?
- Are there certain categories of information that always should be mediated through the communication set?
- What is good/wanted communication?

2 METHOD

The data for the current research was collected through recording the communication between BA firefighters during a warm exercise and through letting the firefighters answer questionnaires about their performance. After action reviews and an interview was also conducted.

2.1 Data collection

The data collection was conducted during three days in Mars 2004 at Ågesta training center, Stockholm Fire Department's training facility for fire, rescue and safety operations. Six exercises were documented in the data collection; two exercises per day with five firemen (four BA firefighters and one BA leader) participating in each exercise.

2.2 Participants

The participants of the entire data collection were 28 male firemen between 27-58 years (M = 40.7; SD = 8.75), all active in Stockholm Community. They had been working as firemen for 2-34 years (M = 15.1; SD = 9.48). According to AFS (AFS 1995:1) a BA firefighter/leader must train at least four times per year, of which two exercises have to be in warm conditions. The participants in the study were at Ågesta to fulfill a part of this requirement. Two of the firemen participated twice in the exercises, once as BA firefighter and once as leader.

Five instructors, responsible for the exercise, also took part in the study. Their role was to answer questionnaires regarding the firemen's performance during the exercise.
The instructors were between 28-46 years (mean = 36.8; SD = 8.17) and had 6-21 years (mean = 11.2; SD = 6.61) of working experience. When not working at Ågesta, they were all working as firemen at different stations in the Community of Stockholm.

The firemen and the instructors were informed about the study and how the data would be collected and treated, and consent was given on the participants' part.

2.2.1 Participants chosen for analysis

Shortly after the collection of data was made, one exercise was chosen for analysis. Out of the 28 firemen, five men, four BA firefighters and one BA leader, were chosen for the communication analysis. They all worked at the same station and were considered to be representative. A detailed description of the participants follows below:

The BA leader
The BA leader was a 48 year old man with 20 years experience of being a fireman.
He had worked with both of the BA firefighters in the first pair, with 1b for 10 years and 1a for 20 years, and he thought he knew them both very well. He did not have as much experience of working with the BA firefighters in the second pair; he had only worked with 2b for 2 years and with 2a for less than 1 year. He estimated that he knew 2b moderately well and 2a poorly.

BA Pair 1
Pair one consisted of 1a and 1b.

- 1a: 52 years old and had been working as a fireman for 31 years.
- 1b: 35 years old and had been a fireman for 11 years.
- 1a and 1b had been working together for 11 years.

According to the answers they gave in the questionnaire, they both felt that they knew each other very well. Since the age limit for a fireman to be a firefighter during BA rescue is 50 years, 1a was no longer an active BA firefighter and usually worked as a BA leader. 1b, on the other hand, was still active.

BA Pair 2
Pair two consisted of 2a and 2b.

- 2a: 46 years old and had 24 years of experience of being a fireman.
- 2b: 38 years old and had been working as a fireman for 15 years.
- 2a and 2b had never worked together before.

Even though 2a and 2b were employees at the same fire station and the same shift, they had not worked together during a BA rescue before. In the questionnaire they both said that they did not know each other and during the interview 2a said that they knew each other as work "mates" but not as professionals. 2a was usually working as a fire chief (*brandmästare*) and was no longer working as a BA firefighter. He participated in the exercise to keep his knowledge about BA rescues fresh since he was about to start working as a BA leader. 2b was an active BA firefighter and had, according to his colleagues, more experience of BA rescues than 2a.

The instructors
All three instructors had worked fulltime at Ågesta three days a week during the spring 2004 and are considered experts in this context.

- The instructor observing the first pair was 33 years old and had 6 years of experience as a firefighter.
- The instructor observing the second pair was 45 years old and had 21years of experience as a firefighter.
- The instructor acting as incident commander and observing the BA leader was 46 years old and had 15 years of experience as a firefighter.

2.3 Apparatus

The exercises being observed in the present research took place in a climate facility, which was designed to train the firemen for warm and non-visual conditions. The facility had no windows and the interior was painted in black, which made it almost impossible to see anything when inside. To simulate heat and to make the exercise physically demanding, the temperature was about 75˚C and the humidity circa 75%. The facility was designed to simulate a building with "mixed activity", that is, a building containing both business-activity and an ordinary apartment, and was built in two floors with a ladder leading from the top floor down to the bottom floor (see appendix A for an approximate plan of the building).

2.3.1 The scenario

A building with mixed activities was filled with smoke and might still contain people. The mission for the BA firefighters was to search the building, starting on the top floor, to try to find possible patients. When they entered the building they did not have information about the bottom floor and finding the ladder quickly was considered as good performance. In the current study there were four patients to be saved, two on the top floor and two on the bottom floor.

The purpose of the exercise was to train the BA pairs' search technique and cooperation, the communication within the team, and the team's ability to work with two pairs of BA firefighters. The exercise also aimed at letting the BA firefighters work hard enough to be able to experience their physical limitations.

2.3.2 Technical equipment

Four throat microphones (especially built for this purpose by Aketoma AB in Stockholm) and mp3 players (Jens of Sweden, MP-300, 256 MB) were used to record the conversation between the BA firefighters and the radio communication was recorded with recording equipment supplied by the personnel at ÅG. The briefing sessions after the exercises were recorded with a mp3 player (iRiver, iHP-120).

To be able to get an overview of the exercise, the BA leader was video recorded (Sony DCR-TRV 330E) and pictures where taken with a digital camera (Fuji Finepix 600S).

2.4 Material

Four different questionnaires were developed inspired by FOI PPS (Pilot Performance Scale) (Castor, Nählinder & Lindström, 2003). The questionnaires were conducted in four versions: one for the BA firefighters, one for the leader, one for the instructors observing the firefighters and one for the instructor (acting as incident commander) observing the BA leader. The purpose of the questionnaires was to measure the overall performance of the BA firefighters and the leader, by letting the firemen estimate their performance themselves (on a scale from 1 to 7). The instructors also estimated the performance of the firemen and their answers were considered as expert opinions. The questions in the questionnaire also aimed at estimating the extent to which the firemen proved to have shared situation awareness, measuring their flexibility/coordination and the quality of the communication, and getting an overview of their thoughts concerning the exercise. (See appendix B 1-4).

2.5 Procedure

Below follows a brief description of the procedure of the data collection, the after action reviews and the interview.

2.5.1 Introductory meeting

The day started with an information meeting in the assembly hall, where the instructors introduced themselves for the visiting firemen. During this assembly the study was also presented and the procedures of the day explained. The firemen themselves chose which of them would be part of the two exercises during the day.

2.5.2 Applying the equipment

Figure 2. The placement of the microphone

After the introductory meeting the firemen changed clothes and went to the depot to collect their BAs. Before putting on the BA the four firemen assigned to be BA firefighters during the exercise were equipped with throat microphones (see Figure 2 for the placement of the throat microphones) and mp3 players. After testing the sound of all four mp3 players the four firemen were gathered and told to count "3-2-1" together. This created a synchronization point in the sound files.

2.5.3 The exercise

Every exercise began when the firemen were still in the depot. One of the instructors, acting as an incident commander, reported the scenario to the BA leader. The leader and the first pair of BA firefighters then took the emergency truck to the exercise site and started the rescue operation. At the same time the second pair of BA firefighters was driven to the climate facility by one of the instructors and was told to wait outside of the facility acting as a reinforced base point. The BA leader then had the option of sending in the second pair when he thought appropriate.

During the exercise three instructors were observing the course of events. Two of the instructors were equipped with BA communication sets and were following the two pairs of firefighters inside the building. The third one was, as mentioned earlier, acting as the incident commander and sat in the control tower overlooking the climate facility. He acted as the center of the exercise by keeping track of all persons involved and what they were doing. To be able to follow the firemen's work inside and outside the facility, the incident commander-instructor had one radio for overhearing the communication between the BA firefighters and leader, one radio for communicating directly with the BA leader (as incident commander) and a third for communication with the other instructors. As the exercise proceeded, depending on the BA firefighters' and the leader's performance, the incident commander informed the BA leader about the number of people left in the building, in which kind of rooms to search, et cetera.

After coming out of the building, the BA firefighters got a few minutes to catch their breath and were then asked to answer the questionnaire, and at the same time the mp3 players were collected. The firefighters were still very tired as they answered the questionnaires but it was considered important that they answered them before they had a chance to talk to each other and reach a consensus about what had happened during the exercise. As soon as the exercise was over the BA leader and the three instructors were asked to answer their questionnaires.

2.5.4 After Action Review

After a short break, during which the firemen had time to shower and change clothes, the instructors gathered the firemen and reviewed the exercise. First the BA firefighters were asked to draw a plan of the building, in which they marked out the rooms they had searched

and where they had found the patients. After reaching a consensus about how the building was constructed, the exercise was discussed in detail. The review and debriefing was recorded with an mp3 player and notes were taken.

After a lunch break a second exercise session, with the same procedures as in the morning, started with a new group of firemen.

2.5.5 Instructor meeting

Seven days after the data collection a meeting took place with the instructors at Ågesta. The purpose was to give them feedback on some of the questions in the questionnaires and to discuss the exercises the week before. A plan of the building, drawn by the author, was validated.

2.5.6 Interview

After a brief review of the recorded material, one of the exercises was chosen for further examination/analysis. Nine days after the exercise took place, an interview was performed at a fire station in Stockholm with two of the firemen who participated in the exercise; one from each BA pair (1a and 2a). Due to differences in schedules the BA leader and the other two firemen could not attend the meeting.

The sound files from the BA firefighters in the first pair and their radio communication with the leader were put together on a mp3-file. The sound was played for the firemen and they were encouraged to comment freely on the material. Difficult passages were commented and clarified. The sound files from the second pair of BA firefighters were also put together but due to technical problems only the first ten minutes of the file could be played. The interview was recorded and notes were taken.

2.6 Limitations

The data collection, with its 28 participants as a whole, generated very much data and due to the time frame of this project the amount of data used for analysis and the amount of analyses of the chosen material was limited. One exercise with two pairs of BA firefighters and one BA leader, as described earlier, was chosen for the communication analysis. Due to differences in performance they were considered suitable for a comparative analysis. A division between three phases in the chosen exercise was made for the analysis:

1) the time period when the first pair was working by itself
2) the relief action
3) the time period when the second pair was working by itself

The BA leader plays an important role in the exercise but his communication was considered somewhat static during phase 1 and 3 and is therefore not subject for analysis in these phases.

3 RESULTS AND DISCUSSION

3.1 Scoring

The sound files from the four BA firefighters and the radio communication were transcribed. In the transcripts, a distinction was made between utterances mediated through the communication set and the utterances mediated through the masks. All utterances and words were counted and then scored according to a modified version of Svensson's (2002) communicative categories (see Figure 3).

Information type 1 – *present activity* – (i1)	
Information, activity, self	Information regarding my position or current activity
Information, activity, other	Information regarding team members' current activity
Information, status, self	Information regarding physical wellness, air supply, fatigue
Information, appearance, building	Information regarding the appearance and construction of the building – reference points
Information type 2 – *future* – (i2)	
Information, intents, self	Information regarding what I intend to do
Information, intents, other	Information regarding what other intends to do
Tactics	
Order/Decision	Ordering new goal, life rescue, etc.
Strategy/Tactics	Sharing and discussing tactics, strategy
Discussion, help/coop	Discussing help/coordination within the team
Request, help/coop.	Urging for help/coordination
Communication –*communicative* (Comm.)	
Confirmation	Confirming or acknowledging information
Denial/Disconfirmation	Disconfirming/rejecting information
Correction/Clarification	Correcting/clarifying information
Repetition of message	Repeating utterance/information
Request clarification	Requesting more or better information/repetition
Question	
Question, activity, other	Asking team members' current activity and position
Question, intents, other	Asking what team members intend to do
Question, status, other	Asking for team members' status
Question, appearance, building	Asking for appearance of the building – reference points
Other – *non-task related*	
Other, regarding practice	Commenting on the practise situation
Other, other issues	Commenting other issues, non-task related
Uncodeable	
Uncodeable	Utterances unintelligible or not fitting

Figure 3. Overview of the communicative categories

Svensson (2002) studied fighter pilots' communication and performance in a military multi-aircraft simulator and formulated seven main communicative categories and 25 subcategories for analyzing utterances. The seven main categories were left intact in this study, but the subcategories have been reformulated to fit the situation in which the firemen work

The categories were presented to a fire chief in Stockholm and examples (presented below) from the recorded material were used to create a concrete picture of how the categories would be used in the analysis. The fire chief reported that he considered the categories to be realistic and after a discussion, only one subcategory was removed from the list of categories.

3.1.1 Examples of the categories

The following examples are taken from the transcripts. In the examples where parts of the utterances are underlined, the underlining aims at pointing out the specific words which made the author decide to categorize the utterance as the category at hand.

Information type 1 – *present activity* – (i1)

Information, activity, self

Informing my position or current activity

2a: I'm standing I'm standing by the ladder now, I'm on my way down

Information, activity, other

Informing of team members' current activity

1a: you are in the kitchen, I am in the reference room

Information, status, self

Informing of physical wellness, air supply, fatigue

Example 1

1b: a, I'm starting to feel tired, well now, now we're standing by the door where we came in .. so now we can put the right hand on the wall here

Example 2

BA-L: oh, do you feel eh, I was thinking about the air and such, over
2b: ah, I have troubles reading mine but I am guessing it says 140

Information, status, building

Informing of the appearance and construction of the building – points of reference

1a: here's a door
1b: ok
1a: no
1b: ah
1a: do you feel a wall on the right side?
1b: yeah, I've hade contact with the wall the whole time there was a shoe shelf on the right side so
1a: shoe shelf?
1b: yeah, a shoe
1a: here is another door
1b: ok … and here is another door too
1a: ah

Information type 2 – *future* (i2)

Information, intents, self

Informing what I intend to do

2a: we are going in and are holding the left hand on the wall

Information, intents, other

Informing what other intends to do

2a: yeah, I am down here on the bottom floor and I've made a close search around the ladder and found nothing
BA-L: ok, is 2b with you too, over
2a: 2b is throwing out the line up there, he is on his way down now

Tactics

Order/Decision

Ordering new goal, instructing, making decisions, et cetera

Example 1 – order/instruction

2b: use the communication set

Example 2 - decision

1b: ah, the thing is that I found a man here who we'll take out so BA leader then, we start life-rescue . we start life-rescue

Strategy/Tactics

Sharing and discussing tactics, strategy

Example 1 - sharing

2a: eh, BA leader, group two, I've reached a doorway on the left side and we are going in there and we're holding the right hand on the wall like they did and see if we find the fire-extinguisher, over

Example 2 - discussing

1a: it seems to be big … we'll take that later then?
1b: what did you say?
1a: ah, it seems to be a bigger room, will we take it now or later?
1b: a, I think we search this room first so we are in control
1a: ok, then we'll continue

Discussion, help/coop

Discussing help/coordination within the team

1a: so you can come up and broaden* besides me and see if you feel the door on your right side
1b: yeah, ah, I broaden here

(* To *broaden* means that the firemen walk side by side, holding the hose between them or holding hands).

Request, help/coop

Urging for help/coordination

2a: can you provide the hose there, it's stuck

Communication –*communicative* (comm.)

Confirmation

Confirming information or acknowledging

1b:	a, BA leader, now we've gone into the reference room again, so now we're going into the second door on the left side then
1a:	here 1b
1b:	jah
BA-L:	ah, you went into door two I heard, over
1a:	ah, that's correct

Denial/Disconfirmation // Correction/Clarification

Disconfirming/rejecting information // Correcting/clarifying information

1a:	a, ok .. then we have one room left in the first room, there was a door, we haven't been in there
1b:	eh, ah, so you mean, in this last room in the reference room?
1a:	no, I mean the first room where we were there was an additional door which we never took
1b:	ok . ah then we'll go to it
1a:	ok
1b:	no, no, no
1a:	ah
1b:	we are where the fire-extinguisher is it is searched through

Repetition of message

Repeating utterance/information

1a:	a, we went straight on the first door on the left side and searched it
BA-L:	eh, can you repeat, over
1a:	a, we took the left hand on the wall and took went into the first room *
BA-L:	ah, that's understood

(* This utterance might not look as a repetition when looking at the words, but semantically it is. In this case, the *first door on the left side* is equivalent to *the first room.*)

Request clarification

Requesting more or better information/repeat

1b:	do you have eh the fire-extinguisher there anywhere?
1a:	yeah, it's here
1b:	ah, good

Question

Question, activity, other

Asking team members' current activity and position

2a:	are you at the doorway?

Question, intents, other

Asking what team members intend to do

2b:	are you coming back?

Question, status, other
Asking for team members' status
Example 1

1a: a, I didn't hear but we should lead them to the kitchen … how do you feel?

Example 2

BA-L: ah, good eh 1b you have been in for about fifteen minutes so I would like to have your air also when you have time, over

Question, appearance, building
Asking for appearance of the building – points of reference

2b: is there a door behind the drapery?
2a: no, it's (*unhearable)*
2b: ok

Other – *non-task related*
Other, regarding practice // Other, other issues
Commenting on the practise situation // Commenting other issues, non-task related

1a: the hose . was that a floor up
1b: yes it probably was .. or is it this .. you
1a: yes
1b: I think it is here
1a: no
1b: there is a hose lying here maybe it is up there too

Uncodeable
Utterances unintelligible or not fitting
Example 1

1a: Jones and
2a: eh
1a: Smith
2a: eh

Example 2

1b: (*unhearable)*

Double and triple categorization
An utterance or word can be categorized into more than one category. Most frequently the utterances/words are only categorized into one category, but on several occasions they are categorized into two or even three categories. Here is an example:

1b: ah, now we've left the reference room again, so we're entering the second door on the left

Compared to the exemplifications of the categories above, 1b's utterance can be classified as i1 (he is informing about the present activity), tactics and i2 (information about entering the second door can be seen both as reporting a tactical move and future activity).

The amount of utterances and words categorized into several categories are presented in the tables later on in the analysis, but due to the time frame of this project, there was no time for a further analysis of this feature.

3.1.2 Consistency in the implementation of the categories

A sample of the transcripts, containing 72 utterances, together with a description of the different categories, was given to an impartial judge person with experience of similar analyses. He was asked to categorize the utterances according to the categories above. The purpose was to see if there was a consistency in the implementation of the categories. There was an absolute agreement between his categorizations and the categorizations made by the author in 62.5% of the utterances. In some cases, the utterances were categorized into more than one category by one or both of the scorers and in 27.7% of the utterances, the utterances were categorized with different amount of categories, but with an agreement of at least one category between the scorers. Only 9.8% of the utterances were categorized completely differently. This is considered to be very positive, as it implies that the categorization was made according to the categories and not according to the author's personal judgments.

3.1.3 Difference-quota

To be able to illustrate the difference between the speakers' amount of utterances (or amount of words) within a pair of speakers, a quota has been calculated.

$$\frac{(\Sigma \text{ speaker 1} - \Sigma \text{ speaker 2})}{(\Sigma \text{ speaker 1} + \Sigma \text{ speaker 2})} = \text{difference-quota}$$

The product of the quota goes from *0.0* to *±1.0*, where 0.0 means that there is no difference between the speakers (e.g. 50 vs. 50 utterances) and ±1.0 means that only one person is speaking (e.g. 100 vs. 0 utterances). With this quota a difference can be calculated between two speakers, based on their current communication pattern, which would show how the utterances/words would be distributed. With the help of this quota the difference in the pair of speakers can be compared with the difference within another pair. In this material, the utterance difference-quota between the BA firefighters in the first pair was 0.071 (16 / 224 = 0.071), this means that when they uttered 224 utterances together there was a discrepancy of 16 utterances between them. If they were to utter 1000 utterances, the discrepancy would be 71 utterances (1000 * 0.071 = 71). The utterance difference-quota for the second pair was 0,065 (13 / 201 = 0.065). When the difference-quotas for the two pairs are compared it can be seen that there hardly was any difference between the two pair's communication patterns concerning utterances; the discrepancy in the amount of utterances was as little between 1a and 1b as between 2a and 2b.

3.2 Course of events during the exercise

To be able to understand the discussion, a brief overview and illustration of the analyzed exercise is in place.

3.2.1 Pair 1

Before entering the exercise facility, the first pair and the BA leader quickly went through the facts they received from the incident commander via radio. The BA leader then sent in the first pair, 1a and 1b, who entered the building, went up the stairs to the second floor and entered the first room (movement (1)). 1a took the lead and they quickly searched through the first room with their left hand against the wall and decided that it would be their reference

room (2). They established that the room had three doors and decided to start with the first door on their left hand. They searched the room with 1a on the left side (3) and 1b on the right (4), both holding their outer hand against the wall and keeping contact between them through the hose or hands. At the end of the room 1b found a door on his right side and did a *close search* outside the door and found the fire-extinguisher. After establishing where the fire-extinguisher was situated they reversed and went back to the reference room.

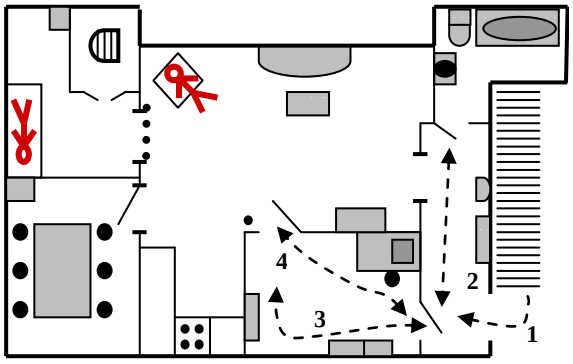

Figure 4. The first moves of Pair 1 (top floor)

Back in the reference room they entered the third room, 1a on the left and 1b on the right (5). 1a soon found the fire-extinguisher and soon thereafter he found the kitchen (6), more or less at the same time 1b found the first patient (7). 1b declared *life-rescue* (*livräddning påbörjas*) and they both carried the patient to the stairwell, where 2a from the second pair collected the patient.

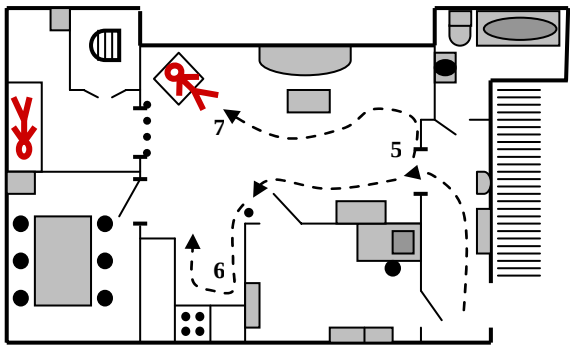

Figure 5. Pair 1's search route finding the first patient (top floor)

Back from the stairwell they went back to where they found the patient and continued their search. 1b found the drapery (8) and the door next to the drapery; 1a did a close search in the room next to the kitchen (9) but considered that it was too big for him to search by himself. Both firefighters entered the room, did a search and established that it was a dining room and then reversed back into room 3. Back in room 3, 1b decided to do a close search behind the drapery and found the second patient and declared *life-rescue* (10). They carried the patient to the stairwell, where 2a met them once more and carried the patient down the stairs.

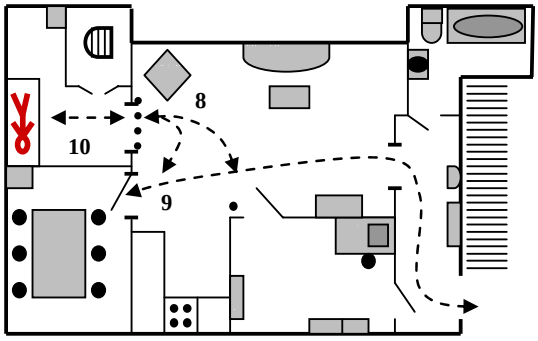

Figure 6. Pair 1's search route finding the second patient (top floor)

After the second patient was out of the building the course of actions began to get confused. The BA leader received information from the incident commander that there was another floor below and that there might still be patients on the new floor. He was informed that the way to the bottom floor was through a ladder behind a drapery. The BA leader reported the same information to the first pair and they decided not to go down the ladder to the bottom floor; they considered themselves pretty tired and wanted to finish the search on the top floor. Since the first pair did not want to go down, the BA leader sent in the second pair, 2a and 2b. The second pair was supposed to go directly to the drapery and down the ladder. 2a and 2b listened to what the first pair was talking about on the communication set before entering the building and decided to go to the second door on the left hand in the reference room.

3.2.2 The relief action

At the same time as the second pair entered the building, there were a couple of minutes of confusion between 1b and 1a in the first pair. Moreover, the second pair somehow ended up in the first room adjacent to the reference room, despite their decision to go to the second door in the reference room. In the doorway or inside this room they met 1a, who lead them out into the reference room. When the two pairs met in the reference room, the confusion was a fact. There was a discussion about where the different BA firefighters were and where they were going and on several occasions there were two different discussions going on simultaneously, both through the radio and through the masks. After several minutes it was decided that 1a would lead the second pair to the drapery and thereafter reunite with 1b and exit the facility.

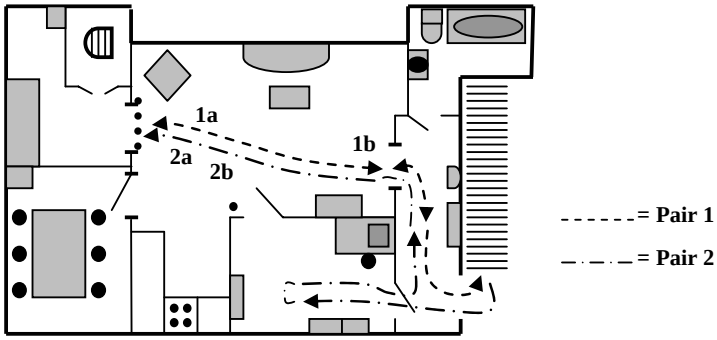

Figure 7. The relief action (top floor)

3.2.3 Pair 2

1a led the second pair to the drapery and then went out together with 1b. After being left by the drapery the second pair had problems with their hose and light line, which took a rather long time for them to solve. After several minutes 2a went down the ladder and 2b sent down the hose. As 2a came down the ladder he did a quick close search around the ladder and found the sofa and the corner (11). When 2b came down it was about 20 min since they had come into the building and they did not have much time left. 2a took the lead and they started their search. The BA leader reported that the patient they were searching for probably was lying in a bathroom and the pair started looking for a bathroom. First they did very brief close searches in the doorways of the two rooms on their right side (12).

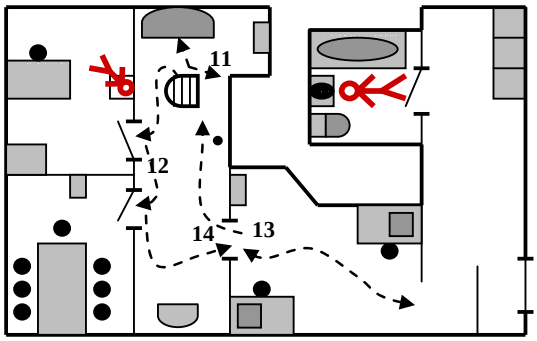

Figure 8. Pair 2's search route on the bottom floor

As they came into the office that leads to the hallway (the right hand office on the plan) 2a and 2b were separated; 2a did the search and 2b was waiting by the doorway (13). They had the hose between them but when 2a asked 2b to come to him 2b could not find him. After a discussion about where they were, they found each other. By now the air was staring to run out and they decided to go up and out (14). 2a climbed the ladder and 2b stayed on the bottom as a discussion about whether they should bring the hose with them or not started. They discussed together with the BA leader and it took several minutes before they decided to leave it downstairs. 2b climbed the ladder and they went out of the building.

3.3 Performance of the two pairs

There was a difference between the two pair's performance and experience of working together. The first pair had worked together for many years and performed well during the exercise, whereas the second pair had never worked together previous to the exercise and performed poorly. The analysis of the communication is based on this difference. See below for a more detailed description of the BA firefighters' and BA leader's estimations of their performance.

3.3.1 Pair 1

Questionnaires

The two men in the first pair had worked together for 11 years and both said that they knew each other well. In the questionnaires the firefighters estimated their performance, communication and other factors related to the exercise and the firefighters' answers in this pair were positively correlated (Pearson r = .5507). The correlation means that the firefighters tended to answer very similarly; if 1a gave his performance a grade 4, 1b gave his performance a similar grade (3-5). This can be said to reflect how well they knew each other.

The answers in the questionnaires indicated that both firefighters were satisfied with their performance during the exercise; they completed their tasks almost perfectly, felt coordinated with each other and thought that they had done a good job. They both said that they were well informed before entering the building and that they were able to create a comprehensive picture of the situation.

When asked about the communication they both graded their ability to mediate information to the colleagues highly. Both wrote that it was easy to understand the partner and that they rarely needed to clarify statements. Misunderstandings occurred rather often but these were solved easily and quickly.

After Action Review and Interview

During the after action review the firefighters' search technique, tactics, communication et cetera, were discussed by all participants in the exercise. Both 1a and 1b said that they were satisfied with the course of events during the exercise, but only to a certain point. A short moment before the second pair entered the building there was a misunderstanding between the firefighters in the first pair (see the discussion about common ground for further details). Even though the misunderstanding between them was rather severe, they were both sure they would have solved the problem quickly if the second pair had not entered the building in the middle of the discussion.

At the meeting the week after the exercise, 1a was still rather pleased with his performance during the exercise. He listened to the sound recording from the exercise and was able to clarify some unclear passages in the recording, especially the confusion at the end. He did not feel as pleased with his pair's performance when he listened to the sound recording as he had been directly after the exercise, but he thought that they both had done a satisfactory job and that there were not many things he thought they would have done differently if they would have the chance to do it over again.

3.3.2 Pair 2

Questionnaires

The firefighters in the second pair had worked at the same station for about two years but never worked together during a BA rescue operation. This was reflected in their questionnaire answers, in which they both said that they did not know each other. It was also reflected in the correlation between their answers, which was not as high as the first pair (Pearson r= .3403). Their correlation means that there was often a rather big difference between how 2a and 2b answered the questions; when 2a answered a question with 7, 2b wrote 3, and the other way around.

Both rated their work as uncoordinated and thought that the co-operation in the group (including the BA-leader) worked rather poorly. Additionally, they both reported that they often felt frustrated due to other persons' actions. When asked about how they completed their tasks the answers differed; 2a thought he completed his tasks moderately well, whereas 2b thought he completed them poorly. But when asked about the overall performance the answers differed even more; 2a was rather pleased (above average) and 2b thought it went as bad as it can go.

There was an agreement between the firefighters when asked about how they managed to orientate in the building. They both thought they managed to familiarize themselves with the

situation in a very good manner and that they were successful in creating points of reference. The instructors, however, thought that they searched and found their way in the building in an unsatisfactory manner. There was a big difference in how well informed they felt before they started the BA rescue (2a was not satisfied with the initial information and 2b was very pleased), but they both said that they could use the information they got from the first pair. There was a discrepancy in the answers about their ability to create a comprehensive picture of the situation; 2a was rather pleased (just above average) and 2b was very pleased (top grade).

The communication was graded very differently by the two men. 2a was not pleased with his ability to mediate information to his colleagues, but 2b was rather pleased. 2a also thought that it was pretty difficult to understand 2b and that misunderstandings occurred very often, whereas 2b reported that he had no problems at all understanding 2a and that hardly any misunderstandings occurred. Both said that confused situations were solved too slowly and that they had to ask their partner to clarify statements very often.

After action review and interview

At the after action review both BA firefighters made clear that they were not satisfied with their performance during the exercise. They mentioned that the lack of experience of working together created problems; 2b was more experienced but 2a was the one who decided how they should work. This resulted in a search tactic which 2b would not have chosen if he had been walking in front. Surprisingly, 2a did not seem to be aware of 2b's frustration during the exercise (see further discussion in the *common ground establishment* paragraph).

The start was also discussed. Due to the confused relief action, both firemen thought that they got a bad start. When, additionally, the hose got stuck when they were about to climb down the ladder they felt that too much time was being lost for them to be able to perform in a satisfactory manner.

3.3.3 The BA leader

The leader of the BA team estimated the two pairs' performance almost identically in the questionnaire. He answered that both pairs informed him about the course of events in a good manner, but that he rather often had to ask for information. He also wrote that he did not have to ask for clarifications very often and that there were not many misunderstandings between him and the BA firefighters. He estimated that both pairs spoke moderately often and that everything they said was relevant.

During the after action review a different picture was reported. At the meeting the BA leader said that he was able to create a satisfactory picture of the situation when the first pair was working but that the second pair was not as good at mediating information about what happened on the inside. For example he did not have an understanding of how the bottom floor was structured.

3.4 Utterance frequency

In this material, an utterance is considered to start when a person opens his mouth to speak and ends when he becomes quiet or another speaker starts to speak. The following example consists of four utterances:

1a:	shoe shelf?
1b:	yeah, a shoe
1a:	here is another door
1b:	ok … and here is another door too

Below follows a description and analysis of the utterance frequency.

3.4.1 Pair 1

Table 1. The first pair's utterances sorted into categories and medium

	1a Total	*1a mask*	*1a com. set*	**1b Total**	*1b mask*	*1b com. set*
Utterances	**120**	76	44	**104**	60	44
i1	**49**	26	23	**29**	9	20
i2	**5**	1	4	**10**	0	10
Tactics	**19**	7	12	**19**	2	17
Comm.	**52**	33	19	**59**	39	20
Question	**23**	17	6	**12**	8	4
Other	**6**	6	0	**5**	5	0
Uncodeable	**4**	4	0	**8**	8	0
Double	28	14	14	24	7	17
Triple	5	2	3	7	2	5

Total amount of utterances in the pair: 224
Difference between the speakers: 16 utterances (difference-quote: .071)

As seen in Table 1, there are some clear differences between how the two firefighters in the first pair communicated.

- They talked differently about the present and future activity (*i1* and *i2, tactics*). It seems as if 1a was the "informer" of the two, whereas 1b was talking more about the future activity than 1a. They talked equally much about tactics, but 1b had twice as many *i2*-utterances than 1a.

- There was a rather big difference in their amount of questions; 1a asked just about twice as many questions as 1b.

- There was also a difference when it comes to uncodeable utterances; 1a had 4 whereas 1b had 8 uncodeable utterances. To a great extent this was probably caused by technical problems; as 1b got tired at the end of the exercise he changed the force of his voice. The throat microphones did not tolerate a too big change of voice force, which resulted in an unclear recording on several occasions.

Concerning medium, both men talked more often via the masks than the communication set except when it regarded tactics and future activity. 1b also talked more about the present activity through the communication set than via the mask.

3.4.2 Pair 2

Table 2. The second pair's utterances sorted into categories and medium

	2a Total	*2a mask*	*2a com.set*	**2b Total**	*2b mask*	*2b com. set*
utterances	**107**	61	46	**94**	47	47
i1	**43**	17	26	**25**	9	16
i2	**3**	0	3	**6**	1	5
Tactics	**23**	13	10	**28**	6	22
Comm.	**34**	17	17	**46**	32	14
Question	**19**	13	6	**16**	6	10
Other	**0**	0	0	**1**	1	0
Uncodeable	**7**	7	0	**4**	4	0
Double	16	4	12	22	9	13
Triple	3	1	2	5	1	4

Total amount of utterances in the pair: 201
Difference between the speakers: utterances 13 (difference-quote: .065)

There are several differences between the two firefighters in the second pair (see Table 2).

- There is a big difference in the amount of utterances about the present activity (*i1*); 2a talked more about this topic than 2b (43 vs. 25 utterances).

- There is also a rather big difference concerning the communicative utterances; the communicative category was 2b's most frequent category, whereas 2a does not have as many utterances categorized into this category.

- 2b talked more about the future activity and tactics than 2a.

- There was also a difference between their uncodeable utterances (7 vs. 4 utterances). Like 1b in the first pair, 2a sometimes increased the force of his voice as he was getting tired.

Concerning the medium, they both talked equally often through the communication set, but 2a talked more through the mask than through the communication set (61 vs. 46 utterances), whereas 2b talked equally much through both mediums (47 vs. 47 utterances). Even though 2a mainly talked via the mask, he talked more frequently about the present and future activity (*i1* and *i2*) through the communication set than through the mask. 2b talked most frequently about most categories via the communication set except communicative utterances. There was a big difference between 2b's communicative utterances mediated through the mask and the communication set (32 vs. 14 utterances).

3.4.3 Comparison – Pair 1 versus Pair 2

There is no difference to speak of in the amount of utterances within and between the two pairs (difference quota pair 1: *.071* vs. pair 2: *.065*). This means that both pairs had the same communication pattern concerning turn-taking. This is not surprising since it is a dialogue, which means that if A says something to B, B is more or less forced to speak next, which naturally leads to this kind of pattern.

Both pairs showed a tendency to create different roles within the pair: the person who walked first (1a and 2a) talked more often than the other. It also seems as if the first firefighter talked more about the present activity than the second, and that the second person mostly just confirmed the first person's utterance. The second person, in both pairs, talked more about tactics than the first. A likely communication pattern that might explain this division is based on the fact that the first person often walks into objects first, he then reports it to his colleague (*i1*), and the colleague then responds and start discussing what to do next (*i2, tactics*).

There is a notable difference between the two pairs regarding the amount of utterances which dealt with tactics (19/19 vs. 23/28). The first pair talked less about tactics than the second pair and this was surprising since the overall impression from listening to the communication was that tactics were little discussed by 2a and 2b. Because of this a more detailed analysis was made of the content of the tactics utterances. The further analysis showed that out of the second pair's 51 tactics utterances, 10 were instructions/orders. The first pair had 4 utterances of the same kind. The use of orders can be seen as a suggestion that the second pair was not very well coordinated; instead of discussing what to do, or simply just acting, they told each other what to do.

The use of communicative utterances also differs between the pairs. It seems as if the first pair confirmed each others' utterances to a greater extent than the second pair. A more detailed description of this phenomenon follows in the next section.

3.5 Utterance length

After a description of the frequency of the utterances it is interesting to see what the utterances contained. Just because a person most frequently talks about tactics does not necessarily mean that tactics is the category in which he uses most words. As we saw above, *i1* and *comm.* were the most frequent categories in both pairs, but in which categories do the firefighters use the greatest amount of words?

3.5.1 Pair 1

Table 3. The first pair's words sorted into categories and medium

	1a Total	*1a mask*	*1a com.set*	**1b Total**	*1b mask*	*1b com.set*
Words	**774**	316	458	**757**	246	511
i1	**472**	154	318	**390**	68	322
i2	**74**	4	70	**186**	0	186
Tactics	**202**	38	164	**319**	42	277
Comm.	**268**	93	175	**278**	127	151
Question	**155**	89	66	**85**	55	30
Other	**17**	17	0	**31**	31	0
Uncodeable	**5**	5	0	**12**	12	0
Double	**310**	83	227	**316**	59	257
Triple	**54**	0	54	**114**	15	99

Total amount of words in the pair: 1531
Difference between the speakers: 17 words (difference-quote: .011)

Table 4. The first pair's mean utterance length (in words)

Mean Utterance Length	*1a – mask*	*1a – com.set*	*1b – mask*	*1b – com.set*
Mean	4.13	10.53	4.10	11.36
i1	5.92	13.83	7.56	16.10
i2	4.0	17.50	0	18.60
Tactics	5.43	13.67	21.0	16.29
Comm.	2.82	9.21	3.26	7.55
Question	5.24	11.0	6.88	7.50
Other	2.84	0	6.20	0
Uncodeable	1.25	0	1.50	0

Both 1a and 1b talked mainly through the communication set, but 1b talked more through the communication set than 1a. When talking through the communication set, both firefighters talked mainly about the present activity (*i1*), but this is not the most frequent utterance category. The most frequent utterances (as seen in the previous paragraph) are communicative ones, but these are often very short.

There is a rather big difference between 1a and 1b when talking through the masks. 1a's most dominating category through the mask, when it comes to the amount of words and *mul* (mean utterance length), is *i1*. On the other hand, the dominant category for 1b, when talking through the mask, is the *communicative* category. 1b also talks much more about the future activity than 1a. This can be seen in the both the number and the length of utterances produced by 1b in the categories *i2* and *tactics*, which are considerably longer than 1a's (1b: 186 and 319 words vs. 1a: 74 and 202 words).

The long utterances belonging to *i1*, *i2* and tactics indicate that they contain a lot of information. The fact that *comm.* is the most frequent category and that those utterances are very short can be seen as a sign of the firefighters' coordination. It seems as if they are very keen on making sure that the partner always understands the information mediated. In several utterances a very interesting pattern can be found:

1. A → B(i1 / i2 / tactics / question)
2. A ← B(comm.)
3. A → B(comm.)

This means that A informs B about something. B then answers with a communicative utterance, showing that he has received the information. A then answers with a communicative utterance to show that he heard that B understood what A said in the first place. Here are two examples:

Example 1:

1b:	do you, eh, have the fire-extinguisher there anywhere?
1a:	yeah, it's here
1b:	ah, good

Example 2:

1a:	is this the door we entered through?
1b:	yes
1a:	good

This pattern appears several times in the transcript and through talking in this way, both speakers make sure that both know what the other one is experiencing. An even more frequent pattern consists of the first two steps of the pattern above; i.e. one person informs the other of something and the recipient of the information confirms that he heard what the other one said.

3.5.2 Pair 2

Table 5. The second pair's words sorted into categories and medium

	2a Total	*2a mask*	*2a com.set*	**2b Total**	*2b mask*	*2b com.set*
Words	**899**	344	555	**676**	180	496
i1	**553**	154	399	**240**	71	169
i2	**90**	0	90	**88**	10	78
Tactics	**323**	128	195	**372**	43	329
Comm.	**243**	73	170	**207**	82	125
Question	**123**	66	57	**113**	33	80
Other	**0**	0	0	**9**	9	0
Uncodeable	**9**	9	0	**7**	7	0
Double	**266**	52	214	**203**	70	133
Triple	**88**	17	71	**79**	3	76

Total amount of words in the pair: 1575
Difference between the speakers: 223 words (difference-quote: .142)

Table 6. The second pair's mean utterance length (in words)

Mean Utterance Length	*2a mask*	*2a com.set*	*2b mask*	*2b com.set*
Mean	5.64	12.07	3.83	10.55
i1	9.06	15.35	7.89	10.56
i2	0	30.0	10	14.18
Tactics	9.85	19.50	7.17	14.95
Comm.	4.29	10.0	2.56	8.93
Question	5.08	9.50	5.50	8.0
Other	0	0	9.0	0
Uncodeable	1.29	0	1.75	0

First of all, it is easily seen in Table 5 that 2a dominated the communication. He did not only have the most utterances, but when he talked he also used longer sentences than 2b (see Table 6). 2a uttered 899 words and had a mean *mul* of 5.64 words for utterances mediated via the mask and 12.07 for the communication set. 2b on the other hand uttered 676 words and had a mean *mul* of 3.83 words for utterances mediated through the mask and 10.55 for the communication set. These features in their communication pattern show that the situation was unequal. The fact that both firefighters had approximately the same amount of utterances and that 2b's utterances were shorter than 2a's, suggests that mostly 2a was speaking and 2b confirming. Moreover, 2a talked very much through the mask, whereas 2b hardly talked through the communication set at all when compared with 2a.

The dissatisfaction that both 2a and 2b showed in the questionnaires and at the after action review and that 2a also showed later during the interview is reflected in their communication. 2a dominated the communication, both through the mask and through the communication set.

He took more space than 2b and talked through the mask more often than his colleague. As mentioned in the utterance frequency section, both talked equally often through the communication set, but 2a talked more often through the mask than 2b. 2b told 2a to use the communication set on several occasions when 2a was talking through the mask, which indicated an irritation about his partner's way of communicating.

Both in the questionnaire and at the after action review 2b reported that he would have done many things differently during the exercise if he would have been in charge. The irritation about the choice of tactics is also displayed in 2b's amount of words in the tactics category mediated through the communication set (329 words vs. 2a's 195). Altogether they have almost the same amount of utterances categorized into the tactics category (323 vs. 372) but the fact that 2b tends to utter his tactics utterances through the communication set can be seen to imply that he also wanted the BA leader to hear him, perhaps to get the support for his ideas he wanted from 2a but did not get.

The 3-turn pattern, seen in the first pair's communication, is not found to the same extent in the second pair's communication. Like the first pair, it is most common with utterances that fit into the first two steps in the pattern, but the third step (the second confirmation) only appears twice. When looking at the transcripts it seems as if the second pair does not have a routine for how to answer each others informing utterances. Here is an example which illustrates rather poor information mediation:

2b: I found a door here, on the right side
2a: ah, I found a door here too
2b: there was a carpet in mine so we'll skip it, we're searching for a bathroom
2a: I'm doing a close search here
2b: ah, I found another door on the right side

What the above example aims at pointing out is how the two men do not check with each other that the other one heard what was said and understood the information. Instead they both answer new information with new and different information. In Swedish, the *ah*'s can be seen as a kind of confirmation, but since it is an open vowel they might just as well be a 'starting sound' before the real utterance. This means that the *ah* might be interpreted as an answer indicating that the partner understood the information, but it might also be a sound without meaning (which only signals that the person is about to say something).

3.5.3 Comparison – Pair 1 & Pair 2

The most obvious difference between the two pairs is probably the difference in equality within the pairs. A comparison of the pairs' word difference-quotas (.011 vs. .142) illustrates that the communication patterns differ considerably. In the first pair, the firefighters are equal; they both get to speak as much as the other. In the second pair, one person leads and talks the most; the other just follows and does not speak as much. When looking closer at the amount of words in every category (the total amount) something very interesting can be spotted. Pair 1's difference quota is very little, but there is a rather large difference between the total amounts of words in the different categories. The second pair, on the other hand, has a comparatively large difference quota, but there is really only one category in which the amount of words differ remarkably; *i1*.

The equality within the pairs can be related to the features of institutional talk. As mentioned earlier, the communication in institutional settings can often be rather unequal (Drew & Heritage, 1992). What is worth noticing in this situation though, is that the two BA

firefighters are supposed to be equal and that the inequality rather is supposed to come up between the firefighters and the leader. The equality between the firefighters in the first pair would be evidence of this, but the communication pattern existing between the men in the second pair might be as common. This feature would be very interesting to study further.

As already mentioned, a 3-turn pattern of communicative utterances could be found to a greater extent in the first pair's communication than in the second pair's. This could indicate that the first pair had experience of talking this way and that it made them coordinated. The second pair did not talk in the same way and seemed to be less coordinated. It can be suggested that the firefighters in the first pair have come up with a communication pattern that fits them, whereas the second pair does not know how to speak to each other. 2a and 2b's ways of speaking differ very much from each other.

3.6 Common ground establishment

Based on the fact that all four firefighters studied in this analysis have many years of experience of being firefighters, are working at the same station, are from the same area of Sweden and so on, they can be considered to have a broad communal common ground (Clark, 1996). Related to team knowledge, they also fulfill most of the requirements which according to Blickensderfer et al. (2000) can be said to constitute pretask team knowledge; the objectives of the team are clear, they all have a lot of experience of the different roles, procedures and equipment, et cetera.

As mentioned previously, there was a major difference in the firefighters' experience of working with each other within the pairs. According to the theory of common ground, the pairs' communication should show signs of the firefighters' knowledge of each other and that is the case; the pairs show different patterns, indicating a differentiation in the establishment of common ground. This can also be put in relation with the element of pretask team knowledge regarding knowledge of the colleagues' characteristics.

3.6.1 Pair 1

The communication between 1a and 1b show signs of a good establishment of common ground. Here is an example:

1a: here's a door
1b: ok
1a: no
1b: ah
1a: do you feel a wall on the right side?
1b: yeah, I've had contact with the wall the whole time there was a shoe shelf on the right side so
1a: shoe shelf?
1b: yeah, a shoe
1a: here is another door
1b: ok … and here is another door too
1a: ah

All through the transcription examples like the one above can be found. As soon as one of the BA firefighters found an object he considered important, he reported it to his colleague, who in turn confirmed the information. This can be tied together with the 3-turn pattern seen in the utterance length discussion. They continuously confirmed each other's utterances when the present or future activity and tactics is discussed, thereby making sure the information mediated was understood by both parts.

A great deal of personal common ground can also be illustrated in this example; working together for many years has resulted in communication patterns which both of them know well. In the questionnaires they both reported to know each other well and this should help their communication.

Pseudo-disagreement in common ground

Even though 1a and 1b showed clear signs of having a good understanding of the situation a pseudo-disagreement occurred. Shortly before the second pair entered the building 1b misunderstood an utterance made by 1a. They were discussing where they were and 1a reported that they were standing in the entrance to the kitchen, which 1b heard as "we are at the entrance of the exercise" (i.e. in the hallway). At the after action review they both reported that they knew where they were but that they thought that the colleague did not know where he was. 1b more or less blamed himself, since he was feeling very tired at the end of the exercise. The misunderstanding never got resolved during the exercise since the second pair entered the hall in the middle of the first pair's discussion, making the situation even more confused (see the section about the relief action for further discussion).

3.6.2 Pair 2

Considering that the firefighters in this pair had never worked together previous to the current exercise being studied, it is not expected that they have so much of a common ground. They do have a communal common ground based on the fact that they are firefighters, working in the same district and at the same station, but there not many signs of an establishment of personal common ground.

Example 1

2a	**I'm down now**
2b	**ah, good I'm sending down the hose to you now then so maybe you can lay a (*unhearable)* so we have a little to move around with**
(32s)	
2b	**how's it going, can you pull a little more?**
2a	**ah, I don't know if much more is needed**
2b	**if you pull a little bit more we have a 25 down there and that can be just right to work with**
(9s)	
2b	to hell with it .. **I'm just going to find my handbag here**

(**BOLD** = mediated through the communication set)

The second pair has a pretty good picture of the situation; they both seem to know where they are in the building and how it is constructed, indicating that they have reached a common ground regarding their environment based on their perceptual experiences. But due to the fact that they have not worked together before they do not know the other person's characteristics, how he talks et cetera, which means that they have not had a chance to reach a personal common ground and, in turn, a common language use. In this example it can be seen how 2b tries to instruct 2a about what to do; he wants 2a to pull the hose until they have 25 meters on the bottom floor, which would give them enough hose to move around freely. 2a on the other hand does not seem to interpret 2b's utterance as an instruction, but rather as a question. The time pressure leaves no space for longer discussions, a fact which seems to be taken into account by 2b who seems to "give in", but not without irritation (which can be seen in the utterance he says for himself via the mask (*to hell with it* (*skit i't då!*)) out of 2a's hearing range).

Example 2

2b	**we'll go back I think there is a dead end under the stairs right?**
2a	yeah
(4s)	
2a	there's a lot of hose here now
(7s)	
2b	**are you coming back or what?**
2a	yeah, it's a dead end here
2b	**use the communication set**
2a	yeah, **it's a dead end, I'm coming back to the stairs here**

This is another example of how the communication between the BA firefighters in the second pair does not work properly. 2b informs his partner that he considers it time to retreat since they are heading towards a dead end under the stairs. 2a replies "yeah", which sounds like a confirmation of 2b's utterance. In the fourth utterance though, "are you coming back or what?", it is understood that 2a never stopped. It seems as if he did not believe 2b's utterance and had to check the truth of it himself, or maybe he just did not hear 2b's utterance but replied in a confirming way anyway. It is imaginable that a communication pattern like this could have put them both in a lot of trouble. If the dead end was instead a hole in the floor and 2a still walked on he could have become severely injured.

3.7 The relief action

The relief action is a very sensitive part of the rescue mission. This is the part of the operation when one pair of BA firefighters reports the necessary information about what they have done, what the interior of the building looks like, and other relevant information to the next pair. If the information transfer goes alright, the second pair can continue where the first pair left off. This means that the better information the next pair gets, the shorter the stop in the rescue operation gets. If the second pair does not get enough information they might have to start over and search the rooms which the first pair has already searched through.

In the questionnaires, both firefighters in the second pair answered that they could use the information mediated by the first pair. The question unfortunately did not cover if it was information mediated through the communication set during the time the first pair was alone in the building or if it was information mediated during the relief action. It was made clear during the interview a week later that the second pair had listened to the first pair's communication to a certain extent and they knew where to go as they entered the building. Even so, they made a wrong turn as soon as they got into the building (as described earlier), ending up in the wrong room.

During the after action review, all firefighters expressed their discontent about the course of events during the relief action. The second pair felt they got off to a bad start and the first pair felt they had been disturbed by the second pair as they entered the building. 1b complained about not having enough space to talk through the communication set; he felt as if the second pair was talking too much through the communication set, making it impossible for 1b to discuss with 1a. The second pair had a different impression of the traffic through the communication set though; they felt as if they had no opportunities at all to talk to each other through the communication set.

The impressions of the communication set traffic made by the four firefighters get very interesting in comparison to how they actually did talk to each other (see Table 7, 8 and 9). In

this phase of the exercise, the BA leader's contributions are also included in the analysis. This was considered important since this is the part when he was talking most frequently (in comparison to the firefighters), acting as a more important part of the communication than during te rest of the operation.

Table 7. The BA team's utterances, divided on persons and medium

Utterances	**1a**			**1b**			**2a**			**2b**			**Ba-l**
	tot	mask	c.set	tot	mask	c.set	tot	mask	c.set	tot	mask	c.set	c.set
Utterances	**29**	10	19	**22**	13	9	**21**	20	1	**29**	25	4	**10**
i1	**10**	3	7	**5**	1	4	**2**	1	1	**5**	4	1	**-**
i2	**3**	-	3	**1**	0	1	**1**	0	1	**1**	1	-	**-**
Tactics	**3**	-	3	**2**	2	-	**3**	2	1	**7**	5	2	**5**
Comm.	**13**	5	8	**10**	5	5	**11**	11	-	**13**	12	1	**6**
Question	**3**	2	1	**2**	1	1	**1**	1	-	**2**	2	-	**1**
Other	**-**	-	-	**0**	-	-	**1**	1	-	**2**	2	-	**-**
Uncodeable	**1**	1	-	**4**	4	-	**4**	4	-	**1**	1	-	**-**
Double	**4**	1	3	**2**	-	2	**0**	-	-	**2**	2	-	**2**
Triple	**0**	-	-	**0**	-	-	**1**	-	1	**0**	-	-	**-**

Table 8. The BA team's amount of words, divided on persons and medium

Words	**1a**			**1b**			**2a**			**2b**			**Ba-l**
	tot	mask	c.set	tot	mask	c.set	tot	mask	c.set	tot	mask	c.set	c.set
Words	**215**	32	183	**163**	67	96	**101**	69	32	**136**	105	31	**120**
i1	**114**	15	99	**51**	8	43	**38**	6	32	**43**	31	12	**-**
i2	**30**	-	30	**25**	12	13	**32**	-	32	**6**	6	-	**-**
Tactics	**55**	-	55	**16**	6	10	**44**	12	32	**40**	24	16	**98**
Comm.	**69**	12	57	**56**	28	28	**24**	24	-	**34**	31	3	**62**
Question	**12**	8	4	**18**	5	13	**4**	4	-	**8**	8	-	**7**
Other	**0**	-	-	**-**	-	-	**5**	5	-	**14**	14	-	**-**
Uncodeable	**2**	2	-	**8**	8	-	**18**	18	-	**1**	1	-	**-**
Double	**67**	5	62	**11**	-	11	**0**	-	-	**10**	10	-	**47**
Triple	**0**	-	-	**0**	-	-	**32**	-	32	**0**	-	-	**-**

Table 9. The BA team's mean utterance length, divided on persons and medium

Mean Utterance Length	***1a mask***	***1a com.set***	*1b mask*	*1b com.set*	***2a mask***	***2a com.set***	*2b mask*	*2b com.set*	***BA leader***
Mean	**3.20**	**9.63**	**5.15**	**10.67**	**3.45**	**32.0**	**4.20**	**7.75**	**12.0**
i1	5.0	14.14	8.0	10.75	6.0	32.0	7.75	12.0	-
i2	-	10.0	12.0	13.0	-	32.0	6.0	-	-
Tactics	-	18.33	3.0	10.0	6.0	32.0	4.80	8.0	19.60
Comm.	2.40	7.13	5.60	5.60	2.18	-	2.58	3.0	10.33
Question	4.0	4.0	5.0	13.0	4.0	-	4.0	-	7.0
Other	-	-	-	-	5.0	-	7.0	-	-
Uncodeable	2.0	-	2.0	-	4.50	-	1.0	-	-

When looking at the total amount of utterances, Table 7 illustrates that all four BA firefighters talked almost equally often (29 / 22 / 21 / 29 utterances). But when the amount of words in the utterances is counted another picture is drawn. Most interesting is the difference between utterances mediated through the communication set and the mask. As seen in Table 8, 1b's impression that there was no space for him to talk through the communication set had no foundation, at least not when it comes to blaming the second pair. 1a was completely dominating the communication set traffic with his 19 utterances (183 words); talking more than the other three firefighters put together. After 1a, the BA leader was talking most frequently through the communication set, mainly communicating with 1a.

Everybody's most frequent utterance category during this phase of the exercise was communicative utterances. During the time the firefighters in the first pair were working alone, 1a functioned as an "informer" and it seems as if he kept this role through the relief action as well. If 1a could be called an informer, 2b's epithet would be a planner; just like during the rest of the exercise, he talked a lot about tactics (7 utterances). The BA leader also discussed tactics to a greater extent than the others (5 utterances). If we look at the utterance length (amount of words, see Table 8), more or less the same pattern reveals itself. There are some slight differences, most interestingly might be the BA leader's amount of words about tactics; even though 2b utters 7 utterances concerning tactics versus the BA leader's 5, the BA leader talks more (98 vs. 40 words). Looking at the amount of words, 1a's role as informer is even more highlighted.

The firefighters in the second pair were forced to talk to each other and the first pair through the masks since there was no space for them to speak through the communication set. 2a utters only one utterance via the communication set and it seems as if he really wanted to take advantage of this one opportunity to speak to mediate his information; 2a's utterance contained 32 words. It is clear that he wanted to mediate as much information as possible when he had the chance.

As MacMillan et al. (2002) pointed out, communication requires cognitive resources. The fact that 1a talked so much through the communication set and with such long utterances (see Table 9) can be seen as an indication that he was tired and that his ability to distinguish between important and unimportant information was diminished. The same can be said about 1b, whose communication set contributions were very long.

When the two pairs met there was a clash between two different goals; the second pair's goal was to start their search, whereas the first pair's goal was to find each other. The second pair needed the first pair's help and guidance to be able to start working, but the first pair gave priority to finding each other instead. It can be considered a bit odd, but the rule for the BA firefighters to never lose physical contact can be seen as the golden rule of BA rescue operations – if direct contact is lost, there is nothing more important than to find each other again. Knowing this rule, it can seem even more odd that the BA leader did not recognize the confusion on the inside and try to solve it. But since all firefighters had a lot of experience of BA rescue operations, it is reasonable to think that the BA leader might have thought that the firefighters would have solved the situation quicker than they did. With the overall performance of the second pair in mind (during the time they worked alone), it can be suggested that they did not receive the appropriate information from the first pair during the relief action.

All four firefighters agreed when asked if the relief action should have been done differently. There were no clear suggestions how they thought it should have been carried out, but they thought it was good to train a situation like this and said it would certainly start a discussion at the station about how to work in the future.

4 GENERAL DISCUSSION

Before returning to the questions stated earlier, a short summary of the most important findings follows. As seen in the previous section, there were several differences, but also similarities, between the pairs' performance and communication.

There were some *similarities* between the two pairs:

- Both pairs showed a *tendency to create roles* within the pair, where the person walking in front frequently talked more about the present activity than the other firefighter. The second person, in turn, talked more about the future activity and tactics.
- The *distribution of utterances mediated through the mask and the communication set* looked rather similar in both pairs. All firemen used shorter utterances when talking through the masks and the utterances uttered through the mask were generally more frequent and very short. This can be due to the effort of screaming; it is easier for the voice to communicate through the communication set.

There are several interesting *differences* between the pairs:

Performance

- The first pair was pleased with their performance and during the after action review all participants reported that the firefighters in the first pair performed as they were supposed to; their performance is therefore considered to be satisfactory.
- The second pair's performance was considered to be unsatisfactory based on their estimations of their performance and the fact that it took about 20 minutes for them to reach the point where they were supposed to start their work.

Communication

- Both pairs had the same turn-taking pattern but there were several differences regarding the content of the utterances. The second pair's communication showed evidence of being rather uncoordinated; partly based on a tendency to give each other orders instead of discussing tactics, but also because of the many misunderstandings that came up. The first pair, on the other hand, more frequently discussed their choice of tactics and displayed a very interesting pattern concerning communicative utterances which seemed to help them make sure that both knew what was going on around them. The first pair's communication can therefore be seen as fairly well coordinated.
- The firefighters in the first pair displayed a very equal communicative pattern concerning the length of their utterances; they talked about different things but both talked equally much. The second pair was not as equal; 2a talked much more than 2b.
- The experience that the first pair had of working together seemed to help them in both their work and communication, whereas the inexperience in the second pairs seemed to create problems. They had not had the chance to create a common language use.

The analysis clearly illustrates some *problems which can occur*:

- Communicative misunderstandings, based on poor common ground and team pretask knowledge, inaccurate choices of words, fatigue or similar phenomena.
- Inaccurate choices of actions based on insufficient information
- 'Bad start' caused by an unstructured relief action.

4.1 Interpretations

Below follows a discussion concerning how the results can help answering the questions posed earlier (at the end of the introductory paragraph).

4.1.1 What in the communication is influencing the performance?

It is difficult to say which features in the pairs' communication patterns that influenced their performance. It can even be suggested that the communication did not influence their performance at all. However, there is some evidence that suggests that the communication did influence the performance. Since the first pair performed in a good manner it can also be suggested that they communicated with each other in a good way. As seen in the analysis, the second pair's performance was unsatisfactory and their poor performance might have been caused by many different factors. Maybe their communication affected their performance in a negative way or their performance might have been negatively influenced by their inexperience of working together. The information mediated by the first pair during the relief action might not have been sufficient and the course of events during their first minutes in the building might have been the reason why they performed poorly. Or maybe something completely different influenced their performance in a negative way?

The firefighters in the first pair showed a more balanced and coordinated communication pattern in comparison to the second pair. They seem to have different roles (they talked about different things) but both got to talk as much as the other and there existed only one misunderstanding. The misunderstanding that did occur was rather severe, but if the firefighters are to be believed, they were certain that the misunderstanding would have been solved quickly if they had not been disturbed by the second pair. This can be questioned; maybe the misunderstanding would not have been solved as quickly as they thought if they would have been left alone. Maybe they had already been inside the building too long and their ability to communicate and work was diminished. Fatigue decreases the ability to distinguish between important and unimportant information and perhaps the first pair should have exited the building earlier, that way avoiding the risk of misunderstandings altogether.

It is reasonable to think that the balance and coordination shown by the first pair influenced their performance in a positive way, whereas the imbalance in roles/domination could have been influencing the second pair's performance in a negative way. The fact that they had no experience of working together previous to the exercise can be seen as a negative factor, influencing both their performance and communication. The communication pattern of the second pair of firefighters in this material would probably be different if they were allowed to practise together a couple of times and then be recorded again. In that case it would not be surprising if the communication pattern would show clearer signs of coordination and have more similarities with the first pair's communication. It does not seem to be a question of whether experience helps (looking at pair 1 it definitely seems to be the case), but rather how a method can be found that helps two firefighters, who have no experience of working together, to communicate in a smooth and efficient way.

4.1.2 What is most crucial; the amount or the content of the communication? What is preferred, much or little communication?

If the assumption that the amount of communication affects the performance of the team, where too little or too much communication affects the performance negatively ("*lagom är bäst*"), is true or not is difficult to answer at this stage. What can be said is that it is rather simple to see that the content of the communication is far more important than the amount. As mentioned in the introduction of the domain, there is an idea among some people within the

force that the firefighters should talk as much as possible during the rescue operations and try to mediate as much information as they can to the BA leader; that way they will say something important at some point. It is difficult to find evidence that would support that idea; just as it is important to make sure that the firefighters do not mediate too little information, too much should probably also be avoided. The BA leader has a cognitively demanding job and should not be exposed to too much information. Even though the leader does not have an equally demanding work situation physically, he also becomes tired and this affects his ability to differentiate between information which is important and other information. How much information that should be mediated is difficult to say, but it is important that the firefighters continuously report what happens on the inside and that they keep their utterances brief enough to make sure that the leader is able to listen to and understand the information.

4.1.3 Are there certain categories of information that always should be mediated through the communication set?

For the BA leader to have a chance to follow the BA firefighters actions on the inside of the building it is reasonable to think that utterances belonging to the *i1*, *i2* and *tactics* should be most important to mediate through the communication set, but there is a problem accompanied with the attempt to answer this question; it is easy to say that utterances belonging to a specific category always should be mediated through the communication set, but with a foundation as weak as this it is dangerous to say that utterances belonging to a specific category should *not* be mediated through the communication set. In some cases it is not possible for the firefighters to choose through which medium to speak; if for example the sound level is too high or if they are too far apart they are forced to use the communication set regardless of the content of the utterance. The situation can also decide that an utterance should be mediated through the mask; as could be seen during the relief action, the second pair was not able to mediate their utterances through the communication set because of the first pair's constant talk.

During talks with the participating firemen of this study it has come to light that some individuals believe that no information at all should be mediated through the mask, but with the documented exercise in mind that seems like an unrealistic approach. During the relief action it would have been impossible for the second pair to communicate if they were not allowed to scream to each other. Imagine if there would have been three pairs of BA firefighters working at the same time and they only had access to one channel. In that case they would more or less have been forced to speak to each other through the masks not to disturb the others. In situations like that it is also becomes even more obvious that it is important that everybody in the team knows which information is important to mediate to everybody or only to the closest colleague.

4.1.4 What is good/wanted communication?

Good communication in this domain can be proposed to be when the speakers are coordinated and understand each other without problems and are able to mediate the information with short sentences and relevant words; making it possible for all people concerned to create an accurate picture of the situation and the actions to be taken.

The opinions amongst the firemen about how this good and wanted communication pattern is to be achieved seem to vary. Previous research and the analysis of the two pairs indicate that experience of working together can be a great help. The firemen in the study conducted by Fogel et al. (2004) reported that listening to the colleague's choice of words and voice could

sometimes help them when trying to picture how demanding the situation on the inside is and when making decisions concerning the team. This ability requires that there is a lot of personal common ground within the pair/team. But if there is no personal common ground it has to be built and that takes time. Considering the theories of common ground (Clark, 1996) and pretask team knowledge (Blickensderfer et al. 2000), it is motivated to think that a common nomenclature could be a starting point for a more successful communication pattern between the BA firefighters. This is additionally supported by Hutchins et al. (1999), who considered the use of homogenous and conventional speech patterns as a great help to accomplish functioning team work. Through a common nomenclature, the firefighters' communication would not depend as much on their personal common ground with their colleagues. The difficulty would then be to reach an agreement about what the nomenclature should cover and what terms to use. If a common nomenclature was to be introduced, it would be vital that the change was done everywhere, making sure that the firefighters from different stations and districts could work together. It is obvious that further research has to be done to be able to see how the firefighters actually do speak and how they want to communicate, and also to investigate the constraints on their communication further to be able to see what kind of changes can be made. Expanding the current study might be a good starting point for gaining further knowledge and finding guiding principles for the BA firefighters' communication and possibly formulating additional heuristics.

4.2 Method discussion

The choice of method and working with the recorded material has helped the author to gain further understanding of the difficulties that comes with the BA team's work, especially the problems which can occur when the communication does not function in a suitable way. Even though a map could be used during the analysis and the communication both through the masks between the firefighters and through the communication set was accessible, it was often very difficult to understand where the BA firefighters were situated in the exercise facility. With this in mind, the difficulties which the BA leader faces in his work was more easily understood; he very seldom has access to a map of the building during rescue operations and can only hear the information mediated through the communication set. The BA leader must therefore work hard to be able to create a mental model of what is happening on the inside and the information mediated by the BA firefighters must be as relevant and clear as possible.

4.2.1 Data collection

The data collection resulted in better data than first expected. The sound quality especially exceeded all expectations; there were only a few problems with the sound quality at short moments due to movement of the microphones or loud screams.

4.2.2 Questionnaires

The questions in the questionnaires generally worked well and supplied a good foundation for the communication analysis, but the reliability of the answers can be challenged to a certain extent. Having been in the exercise facility for about 30 minutes, the firefighters were very tired when they answered the questionnaires. It was considered important that they gave their answers as soon as possible after the exercise to make sure that the course of events during the exercise was fresh in mind and that no consensus between the firefighters was reached. The fatigue and physical exhaustion might have decreased the firefighters' ability to understand and answer the questions. One example of this was the questionnaire filled in by the BA leader, in which he was supposed to estimate the performance of the two pairs. Even

though the performance of the pairs differed rather strikingly, he estimated their performance almost identically on all questions. At the meeting afterwards he mentioned differences between the pairs which he had not noted in the questionnaire. If the firemen would have been allowed to wait longer before they answered the questionnaires they might have been more relaxed and concentrated on the questions, but on the other hand there would have been a risk that the firemen in the pairs would have talked about the exercise and reached a consensus about what they thought about the exercise, leaving out negative thoughts or things they did not agree on in their answers.

4.2.3 Analysis

Whereas the procedure of the data collection was well planned, the choices of analysis methods were made as the work progressed. The choice of doing a qualitative analysis mixed with quantitative elements, by looking at phenomena such as common ground but also by categorizing and counting the utterances, was based on a wish to work within the rather loose framework given by qualitative methods but also be able to give concrete examples of how the communication looked with the help of figures. The mixture of the two ways of working functioned in a satisfactory manner and gave interesting and informative results.

As mentioned in the section 'categorizing language', there are some problems accompanied with the attempt to categorize language that should be stressed. One risk is that the categories are too few, general and 'generous', and another risk is to use too many categories, which are too specific. Too few or too many categories may result in evidence for interpretations which are not really there being found or an inability to point out interesting features in the communication. With this in mind, the choice of categories for the current study was very important and difficult. Svensson's categories were chosen since they were considered neither too general nor specific and because they capture most of the features which characterize the communication in the fire-fighting domain. One threat to the reliability of the categorisation is that the utterances often can be categorized into several categories, leading to a categorization that can be thought of as rather arbitrary; but as seen in the introduction of the categories, there was only a discrepancy of 9.8% between the categorizations made by the author and an impartial judge person, which is considered to be a very positive result of the consistency of the categorization. Another thing that also should be mentioned about the categories used in the study is that only the main categories were used in the analysis. The subcategories were only used in the analysis of the tactics utterances, as described earlier, but if there would have been more time for the analysis, it would have been interesting to see how the utterances were distributed into the subcategories as well as the main categories.

The five firemen chosen for the communication analysis are considered to be representative but this does not mean that the results might not have been different with another group of firemen. The communication patterns are very individual and more research must be done before the features found in an investigation such as this one can be said to be valid for all firemen working with BA firefighting. There is also a possible risk that the communication patterns found in these recordings might not even be transferable to the firemen in the exercise during real life operations. Since they were recorded during an exercise, the situation is not the same as real BA rescue operations; there was e.g. no fire or threats. Even though the firemen and instructors considered the exercise to be very realistic and physically demanding, it is a fact that the strong threats of the fire and smoke were not present during the exercise. It is therefore possible that the communication patterns of the same firemen, in the same pair constellation, might be considerably different during a real BA rescue operation.

4.3 Future research

The data collection conducted in the current research generated far more data than could be analyzed within the timeframe of the project. It would be very interesting to listen to and analyze the rest of the material to see if the same kind of communicative patterns can be found in the other pair's communication.

The BA leader's role in the rescue operation is obviously important and could unfortunately not be given enough attention in this project. In the future, a thorough study of BA leaders' abilities to handle the information flow and pick up relevant clues in the surrounding could be fruitful. Further understanding of the cognitive requirements and constraints accompanied with the BA leader's work could help define what kind of information he needs from the BA firefighters.

As seen earlier, the relief action can strongly influence the performance of the next pair of BA firefighters. There are different methods for how the relief action can be conducted, but the methods are not strictly defined and during rescue operations the relief action seems to be haphazard or based on habit rather than on conscious choices. While discussing communication with the personnel at Ågesta, complaints about 'fuzzy' guidelines regarding the relief action came up. The people working at Ågesta seemed to be motivated to learn more about different methods and how and when they should be implemented. A study concerning relief actions could be of great help for the firefighters in the future.

Another area which would be interesting to study is how the physical strain affects the communication. This could be done through psychophysiological measuring simultaneous to the recording of the communication. Through a study of that kind it would be possible to see how fatigue and exhaustion influences the firefighters ability to communicate with each other. Knowing the effects of psychophysiological processes on communication, the firefighters can be made aware of and more quickly discover the 'communicative symptoms' related to fatigue and exhaustion.

5 CONCLUSIONS

There is an imminent risk that communicative problems in the shape of misunderstandings, an inability to coordinate the communication or similar phenomena, affect the performance negatively. Not only do communicative problems affect the performance of the pair of BA firefighters; the whole team is affected. This study illustrates the importance of functioning communication in the BA team and the need for further research within the area. During BA rescue operations on a larger scale, BA firefighters might have to work with colleagues from other districts and stations, with which they have never worked together before. In those situations it is of special importance that there is some kind of consensus for how the communication should be in order to communicate and work in an efficient manner.

There is a need to put some effort into trying to find out what effective communication during BA rescue really is. This thesis has come a bit on the way, but there are still more questions than answers. Due to the complex work situation it is very difficult to formulate specific and strict rules regarding the communication, but there is a definite need for clearer guidelines than the few that exist today. It is obvious that the firefighters possess a lot of tacit knowledge about their work procedures and communication, and if more of that knowledge can be articulated, the BA firefighters can be aided to improve their work situation. If the firefighters can be helped to communicate with each other without the need of long experience of working together, a lot of time, effort, and lives could be saved.

At this stage, a suggestion might be to formulate a common nomenclature for the BA firefighters, but this suggestion is to be taken with precaution; before any change of that kind is initiated, research has to be conducted to see what parts of the communication are suitable to change into fixed terms and what impact a change of that kind would have on the BA team's performance. If the communication can be made more homogenous within the fire brigade, less time would have to be spent on communication and decisions could be made more quickly.

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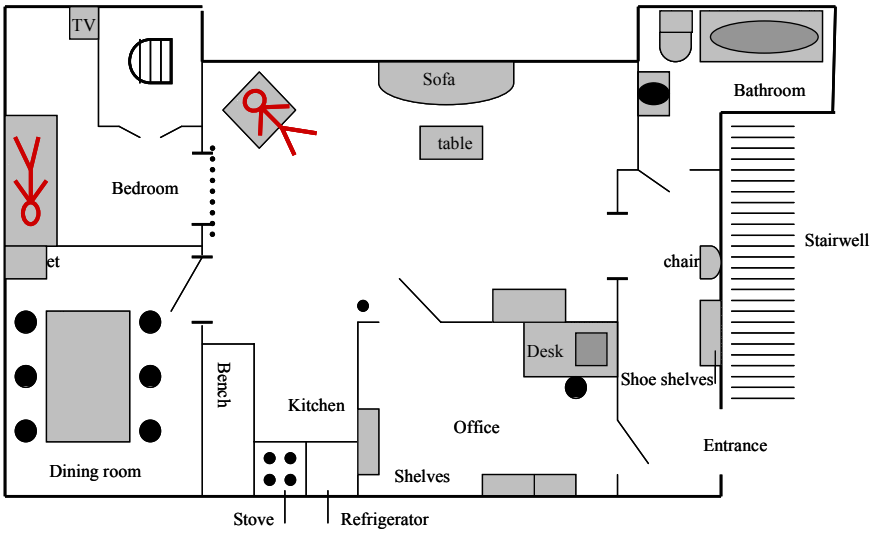
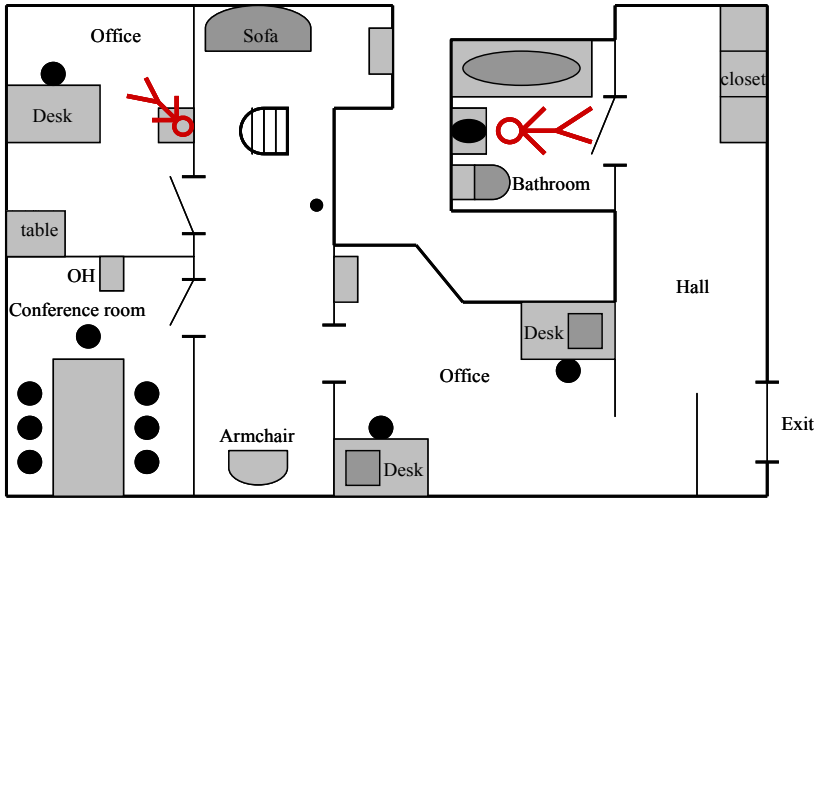
7 APPENDIX

7.1 Appendix A: plan of the climate facility at Ågesta training centre

Top floor



Bottom floor



7.2 Appendix B- 1

Datum:
Klockslag:
Mp3spelare:

RÖKDYKARE

Vi är två studenter vid Linköpings universitet som genomför en studie om rökdykning i samarbete med Totalförsvarets Forskningsinstitut (FOI). Enkäten framför Dig är en del av denna studie och vi ber därför om Din hjälp med att svara på några frågor. Dina svar kommer att behandlas konfidentiellt och vi garanterar din anonymitet.

Det är 31 frågor som ska besvaras av dig. Har du några frågor så finns vi i närheten för att förtydliga. Säg bara till.

Svaren ska lämnas individuellt och ej diskuteras med kollegorna under besvarandet.

Tack för Din medverkan!
Annelie & Ida

Namn:

Ålder:

År i yrket:

Arbetsplats (brandstation):

Kryssa i vilken roll du hade under övningen: Rökdykare 1 ☐ Rökdykare 2 ☐

1. **Har du tidigare arbetat tillsammans med din kollega under övningen?**
   Ja ☐ **Nej** ☐

   Om ja:
   - **hur länge?_____ år**
   - **hur väl känner ni varandra?**

   Inte väl 1 2 3 4 5 6 7 Mycket väl

2. **Hur svår tycker du att övningen var?**

   Mycket lätt 1 2 3 4 5 6 7 Mycket svår

3. **Hur utmanande var övningen?**

   Inte alls 1 2 3 4 5 6 7 Mycket

4. **Kände du dig stressad under övningen?**

   Inte alls 1 2 3 4 5 6 7 Hela tiden

5. **Hur löste du dina uppgifter?**

   Inte alls 1 2 3 4 5 6 7 Perfekt

6. **Hur nöjd är du med din insats som helhet?**

   Inte alls nöjd 1 2 3 4 5 6 7 Mycket nöjd

7. **Hur fungerade samarbetet inom <u>rökdykargruppen</u> (rökdykare och rökdykarledare)?**

   Inte särskilt bra 1 2 3 4 5 6 7 Bästa möjliga

8. **Hur väl samordnade var era handlingar i <u>rökdykarparet</u> under övningen?**

   Inte alls 1 2 3 4 5 6 7 Mycket samordnade

9. **Hade du lätt för att anpassa dig efter din kollega (i paret)?**

   Inte alls 1 2 3 4 5 6 7 Mycket lätt

10. I vilken utsträckning löste det rökdykarpar som du tillhörde de uppgifter som ni blivit tilldelade?

Inte alls 1 2 3 4 5 6 7 I allra högsta grad

11. Hur välinformerade var ni innan ni påbörjade rökdykningen?

Inte alls 1 2 3 4 5 6 7 Mycket välinformerade

12. I vilken utsträckning upplevde du att du var tvungen att förändra/anpassa ditt agerande till din kollegas?

Mycket liten 1 2 3 4 5 6 7 Mycket stor

13. Kände du dig någon gång frustrerad på grund av andra personers agerande?

Inte alls 1 2 3 4 5 6 7 Mycket ofta

14. I vilken utsträckning upplevde du att du kunde skapa dig en övergripande bild av situationen?

Mycket liten 1 2 3 4 5 6 7 Mycket stor

15. Upplevde du att ni låg ”ett steg före” i händelseförloppet under övningen?

Inte alls 1 2 3 4 5 6 7 Hela tiden

16. Blev du överraskad av något i händelseförloppet under övningen?

Aldrig 1 2 3 4 5 6 7 Ofta

Om ja, av vad?_____

17. I vilken utsträckning karaktäriserades övningen av oförutsedda händelser?

Mycket liten 1 2 3 4 5 6 7 Mycket stor

18. I vilken utsträckning upplevde du att du kunde förutsäga händelseutvecklingen?

Mycket sällan 1 2 3 4 5 6 7 Hela tiden

19. Hur lång tid tog det för er inom paret att ”reda upp” situationer där något blivit fel/förvirrat?

Alldeles för länge 1 2 3 4 5 6 7 Mycket kort tid

20. Hur lyckades ni med att orientera er i lokalen?

Inte alls bra 1 2 3 4 5 6 7 Mycket bra

21. Hur många rum sökte ni igenom? _____

22. Hur väl kunde ni skapa er referenspunkter i lokalen?

Inte alls väl 1 2 3 4 5 6 7 Mycket väl

23. I hur stor utsträckning hade du ”koll på läget” under övningen?

Inte alls 1 2 3 4 5 6 7 Till fullo

24. I vilken utsträckning upplevde du att du kunde förmedla information till dina kollegor inom rökdykargruppen på ett tillfredställande sätt?

Inte alls 1 2 3 4 5 6 7 Till fullo

25. I vilken utsträckning uppstod missförstånd inom rökdykargruppen under övningen?

Mycket sällan 1 2 3 4 5 6 7 Mycket ofta

26. I vilken utsträckning behövde du be din kollega att förtydliga ett yttrande?

Mycket sällan 1 2 3 4 5 6 7 Mycket ofta

27. Upplevde du rökdykarledarens kommunikation som störande i ditt arbete?

Inte alls 1 2 3 4 5 6 7 Mycket störande

28. I vilken utsträckning kunde du utnyttja information som kom från det första rökdykarparet?

Inte alls 1 2 3 4 5 6 7 Till fullo

☐ Jag tillhörde det första rökdykarparet

29. Hade du lätt för att förstå din kollega (i paret)?

Inte alls 1 2 3 4 5 6 7 Mycket lätt

30. Hur lärorik var övningen?

Inte alls lärorik 1 2 3 4 5 6 7 Mycket lärorik

31. Om du fick göra om övningen, skulle du vilja göra något annorlunda?

Om ja, vad?_____

_____

_____

_____

Tack för din medverkan!
Annelie & Ida

7.3 Appendix B- 2

Datum:
Klockslag:

RÖKDYKARLEDARE

Vi är två studenter vid Linköpings universitet som genomför en studie om rökdykning i samarbete med Totalförsvarets Forskningsinstitut (FOI). Enkäten framför Dig är en del av denna studie och vi ber därför om Din hjälp med att svara på några frågor. Dina svar kommer att behandlas konfidentiellt och vi garanterar din anonymitet.

Det är 28 frågor som ska besvaras av dig. Har du några frågor så finns vi i närheten för att förtydliga. Säg bara till.

Svaren ska lämnas individuellt och ej diskuteras med kollegorna under besvarandet.

Tack för Din medverkan!

Annelie & Ida

Namn: _____

Ålder: _____

År i yrket: _____

Arbetsplats (brandstation): _____

1. **Har du tidigare arbetat tillsammans med de som var rökdykare under övningen?**
   Ja ☐ Nej ☐

   För varje kollega du tidigare arbetat med, fyll i:

   - **Namn_____**
   - **hur länge?_____ år**
   - **hur väl känner ni varandra?**

     Inte väl 1 2 3 4 5 6 7 Mycket väl

   - **Namn_____**
   - **hur länge?_____ år**
   - **hur väl känner ni varandra?**

     Inte väl 1 2 3 4 5 6 7 Mycket väl

   - **Namn_____**
   - **hur länge?_____ år**
   - **hur väl känner ni varandra?**

     Inte väl 1 2 3 4 5 6 7 Mycket väl

   - **Namn_____**
   - **hur länge?_____ år**
   - **hur väl känner ni varandra?**

     Inte väl 1 2 3 4 5 6 7 Mycket väl

2. **Hur svår tycker du att övningen var?**

   Mycket lätt 1 2 3 4 5 6 7 Mycket svår

3. Hur utmanande var övningen?

Inte alls 1 2 3 4 5 6 7 Mycket

4. Kände du dig stressad under övningen?

Inte alls 1 2 3 4 5 6 7 Hela tiden

5. Hur löste du dina uppgifter?

Inte alls 1 2 3 4 5 6 7 Perfekt

6. Hur nöjd är du med din insats som helhet?

Inte alls nöjd 1 2 3 4 5 6 7 Mycket nöjd

7. Hur fungerade samarbetet inom rökdykargruppen (rökdykare och rökdykarledare)?

Med första rökdykarparet:

Inte särskilt bra 1 2 3 4 5 6 7 Mycket bra

Med andra rökdykarparet:

Inte särskilt bra 1 2 3 4 5 6 7 Mycket bra

8. Kände du dig någon gång frustrerad på grund av andra personers agerande?

Inte alls 1 2 3 4 5 6 7 Mycket ofta

9. Upplevde du att du låg ”ett steg före” i händelseförloppet under övningen?

Inte alls 1 2 3 4 5 6 7 Hela tiden

10. Hur välinformerad var du innan ni påbörjade rökdykningen?

Inte alls 1 2 3 4 5 6 7 Mycket välinformerade

11. Blev du överraskad av något i händelseförloppet under övningen?

Aldrig 1 2 3 4 5 6 7 Ofta

Om ja, av vad?_____

12. I vilken utsträckning karaktäriserades övningen av oförutsedda händelser?

Mycket liten 1 2 3 4 5 6 7 Mycket stor

13. I vilken utsträckning upplevde du att ni kunde koordinera era arbetsuppgifter inom rökdykargruppen?

Inte alls 1 2 3 4 5 6 7 Till fullo

14. I vilken utsträckning upplevde du att du kunde förutsäga händelseutvecklingen?

Mycket sällan 1 2 3 4 5 6 7 Mycket ofta

15. Till vilken grad upplevde du att du lyckades skapa dig en uppfattning om hur lokalen såg ut på insidan?

Inte alls 1 2 3 4 5 6 7 Till fullo

16. Upplevde du att du visste var i byggnaden rökdykarna befann sig?

Med första rökdykarparet:

Mycket sällan 1 2 3 4 5 6 7 Hela tiden

Med andra rökdykarparet:

Mycket sällan 1 2 3 4 5 6 7 Hela tiden

17. Hur många rum uppfattade du att rökdykarna genomsökte?

*Första rökdykarparet:*_____

*Andra rökdykarparet:*_____

18. I hur stor utsträckning hade du ”koll på läget” under övningen?

Inte alls 1 2 3 4 5 6 7 Till fullo

19. I vilken utsträckning upplevde du att du kunde förmedla information till dina kollegor inom rökdykargruppen på ett tillfredställande sätt?

Inte alls 1 2 3 4 5 6 7 Till fullo

20. Hur ofta var du tvungen att efterfråga information från rökdykarna?

Med första rökdykarparet:

Mycket sällan 1 2 3 4 5 6 7 Mycket ofta

Med andra rökdykarparet:

Mycket sällan 1 2 3 4 5 6 7 Mycket ofta

21. I vilken utsträckning uppstod missförstånd mellan dig och rökdykarna under övningen?

Med första rökdykarparet:

Mycket sällan 1 2 3 4 5 6 7 Mycket ofta

Med andra rökdykarparet:

Mycket sällan 1 2 3 4 5 6 7 Mycket ofta

22. I vilken utsträckning behövde du be dina kollegor att förtydliga ett yttrande?

Med första rökdykarparet:

Mycket sällan 1 2 3 4 5 6 7 Mycket ofta

Med andra rökdykarparet:

Mycket sällan 1 2 3 4 5 6 7 Mycket ofta

23. I vilken utsträckning kunde du utnyttja information som kom från det första rökdykarparet för att ”briefa” det andra paret?

Inte alls 1 2 3 4 5 6 7 Till fullo

24. Upplevde du att du fick tillräcklig information om händelseförloppet av rökdykarna?

Från första rökdykarparet:

Inte alls 1 2 3 4 5 6 7 Definitivt

Från andra rökdykarparet:

Inte alls 1 2 3 4 5 6 7 Definitivt

25. Skatta mängden radiokommunikation från <u>första</u> rökdykarparet under övningen.

För lite 1 2 3 4 5 6 7 För mycket
Lagom

Hur mycket var relevant?

Mycket lite 1 2 3 4 5 6 7 Allt

26. Skatta mängden radiokommunikation från <u>andra</u> rökdykarparet under övningen.

För lite 1 2 3 4 5 6 7 För mycket
Lagom

Hur mycket var relevant?

Mycket lite 1 2 3 4 5 6 7 Allt

27. Hur lärorik var övningen?

Inte alls lärorik 1 2 3 4 5 6 7 Mycket lärorik

28. Om du fick göra om övningen, skulle du vilja göra något annorlunda?

Ja ☐ Nej ☐

Om ja, vad?_____

_____

_____

_____

Tack för din medverkan!

Annelie & Ida

7.4 Appendix B- 3

Datum:

Klockslag:

INSTRUKTÖR rökdykare

Vi är två studenter vid Linköpings universitet som genomför en studie om rökdykning i samarbete med Totalförsvarets Forskningsinstitut (FOI). Formuläret framför Dig är en del av denna studie och vi ber därför om Din hjälp med att bedöma hur teamet utför de olika momenten under övningen. Dina svar kommer att behandlas konfidentiellt och vi garanterar din anonymitet.

Det är 26 frågor som ska besvaras av dig. Har du några frågor så finns vi i närheten för att förtydliga. Säg bara till.

Svaren ska lämnas individuellt och ej diskuteras med kollegorna under besvarandet.

Tack för Din medverkan!
Annelie & Ida

Namn:

Ålder:

År i yrket:

Arbetsplats (brandstation):

1. **Hur svår tycker du att övningen var för rökdykargruppen?**

   Mycket lätt 1 2 3 4 5 6 7 Mycket svår

2. **Hur utmanande var övningen för rökdykargruppen?**

   Inte alls 1 2 3 4 5 6 7 Mycket

3. **Hur löste gruppen sina uppgifter?**

   Inte alls 1 2 3 4 5 6 7 Perfekt

4. **Hur fungerade samarbetet inom <u>rökdykargruppen</u> (rökdykare och rökdykarledare)?**

   Inte särskilt bra 1 2 3 4 5 6 7 Perfekt

5. **Hur väl samordnade var handlingarna i <u>rökdykarparet</u> under övningen?**

   Inte alls 1 2 3 4 5 6 7 Mycket samordnade

6. **Upplevde du att rökdykarna hade lätt för att anpassa sig till varandra (i paret)?**

   Inte alls 1 2 3 4 5 6 7 Mycket lätt

7. **I vilken utsträckning löste rökdykarparet de uppgifter som de blivit tilldelade?**

   Inte alls 1 2 3 4 5 6 7 I allra högsta grad

8. **I vilken utsträckning karaktäriserades övningen av oförutsedda händelser?**

   Liten utsträckning 1 2 3 4 5 6 7 Stor utsträckning

9. **I vilken utsträckning upplevde du att rökdykarparet kunde förutsäga händelseutvecklingen?**

   Liten utsträckning 1 2 3 4 5 6 7 Stor utsträckning

10. **Hur lång tid tog det för paret att ”reda upp” situationer där något blivit fel/förvirrat?**

    Alldeles för länge 1 2 3 4 5 6 7 Mycket kort tid

11. Hur lyckades rökdykarna med att orientera sig i lokalen?

Inte alls bra 1 2 3 4 5 6 7 Mycket bra

12. Hur många rum sökte de igenom? _____

13. Hur väl kunde rökdykarna skapa sig referenspunkter i lokalen?

Inte alls väl 1 2 3 4 5 6 7 Mycket väl

14. Kom rökdykarna snabbt överens om en sökteknik?

Inte alls 1 2 3 4 5 6 7 Mycket snabbt

Var denna sökteknik lämplig i sammanhanget?

Inte alls 1 2 3 4 5 6 7 Mycket lämplig

15. I hur stor utsträckning hade rökdykarna ”koll på läget” under övningen?

Inte alls 1 2 3 4 5 6 7 Till fullo

16. Hur väl lyckades rökdykarna skapa och bibehålla en säker reträttväg?

Inte alls 1 2 3 4 5 6 7 Mycket väl

17. I vilken utsträckning upplevde du att rökdykarna kunde förmedla information mellan varandra på ett tillfredställande sätt?

Inte alls 1 2 3 4 5 6 7 Till fullo

18. I vilken utsträckning upplevde du att rökdykarna kunde förmedla information till rökdykarledaren på ett tillfredställande sätt?

Inte alls 1 2 3 4 5 6 7 Till fullo

19. I vilken utsträckning uppstod missförstånd inom rökdykargruppen under övningen?

Inte alls 1 2 3 4 5 6 7 Mycket ofta

20. Upplevde du att rökdykarledarens kommunikation störde rökdykarnas arbete?

Inte alls 1 2 3 4 5 6 7 Mycket störande

21. Upplevde du att rökdykarledarens kommunikation stöttade rökdykarnas arbete?

Inte alls 1 2 3 4 5 6 7 Till stor del

22. Skatta mängden radiokommunikation från rökdykarna under övningen.

För lite 1 2 3 4 5 6 7 För mycket
Lagom

Hur mycket var relevant?

Mycket lite 1 2 3 4 5 6 7 Allt

23. I vilken utsträckning hade rökdykarna ”koll på” hur mycket krafter den andre i paret hade kvar?

Inte alls 1 2 3 4 5 6 7 Till fullo

24. I vilken utsträckning hade de båda rökdykarna använt lika mycket av sin kapacitet efter avslutat pass?

Inte alls 1 2 3 4 5 6 7 Till fullo

25. Om de fick göra om övningen, borde de göra något annorlunda? Ja ☐ Nej ☐

Om ja, vad?_____

_____

_____

_____

_____

_____

26. Finns det något den här gruppen borde träna mer på?

_____

_____

_____

_____

Tack för din medverkan!
Annelie & Ida

7.5 Appendix B- 4

Datum:

Klockslag:

INSTRUKTÖR rökdykarledare

Vi är två studenter vid Linköpings universitet som genomför en studie om rökdykning i samarbete med Totalförsvarets Forskningsinstitut (FOI). Formuläret framför Dig är en del av denna studie och vi ber därför om Din hjälp med att bedöma hur teamet utför de olika momenten under övningen. Dina svar kommer att behandlas konfidentiellt och vi garanterar din anonymitet.

Det är 23 frågor som ska besvaras av dig. Har du några frågor så finns vi i närheten för att förtydliga. Säg bara till.

Svaren ska lämnas individuellt och ej diskuteras med kollegorna under besvarandet.

Tack för Din medverkan!

Annelie & Ida

Namn:

Ålder:

År i yrket:

Arbetsplats (brandstation):

1. **Hur svår tycker du att övningen var för rökdykarledaren?**

   Mycket lätt 1 2 3 4 5 6 7 Mycket svårt

2. **Hur utmanande var övningen för rökdykarledaren?**

   Inte alls 1 2 3 4 5 6 7 Mycket

3. **Hur löste rökdykarledaren sina uppgifter?**

   Inte alls 1 2 3 4 5 6 7 Perfekt

4. **Hur fungerade samarbetet inom rökdykargruppen (rökdykare och rökdykarledare)?**

   Med första rökdykarparet:

   Inte särskilt bra 1 2 3 4 5 6 7 Perfekt

   Med andra rökdykarparet:

   Inte särskilt bra 1 2 3 4 5 6 7 Perfekt

5. **Upplevde du att rökdykarledaren låg ”ett steg före” i händelseförloppet under övningen?**

   Inte alls 1 2 3 4 5 6 7 Hela tiden

6. **I vilken utsträckning karaktäriserades övningen av oförutsedda händelser?**

   Liten utsträckning 1 2 3 4 5 6 7 Stor utsträckning

7. **I vilken utsträckning upplevde du att rökdykargruppen kunde koordinera sina arbetsuppgifter?**

   Rökdykarledare + första rökdykarparet:

   Liten utsträckning 1 2 3 4 5 6 7 Stor utsträckning

   Rökdykarledaren + andra rökdykarparet:

   Liten utsträckning 1 2 3 4 5 6 7 Stor utsträckning

8. I vilken utsträckning upplevde du att rökdykarledaren kunde förutsäga händelseutvecklingen?

Liten utsträckning 1 2 3 4 5 6 7 Stor utsträckning

9. Till vilken grad uppskattar du att rökdykarledaren lyckades skapa sig en uppfattning om hur lokalen såg ut på insidan?

Inte alls 1 2 3 4 5 6 7 Till fullo

10. Upplevde du att rökdykarledaren visste var i byggnaden rökdykarna befann sig?

Med första rökdykarparet:

Mycket sällan 1 2 3 4 5 6 7 Hela tiden

Med andra rökdykarparet:

Mycket sällan 1 2 3 4 5 6 7 Hela tiden

11. I hur stor utsträckning hade rökdykarledaren ”koll på läget” under övningen?

Liten utsträckning 1 2 3 4 5 6 7 Stor utsträckning

12. I vilken utsträckning upplevde du att rökdykarledaren kunde förmedla information till sina kollegor inom rökdykargruppen på ett tillfredställande sätt?

Till första rökdykarparet:

Inte alls 1 2 3 4 5 6 7 Till fullo

Till andra rökdykarparet:

Inte alls 1 2 3 4 5 6 7 Till fullo

13. Hur ofta var rökdykarledaren tvungen att efterfråga information från rökdykarna?

Med första rökdykarparet:

Mycket sällan 1 2 3 4 5 6 7 Mycket ofta

Med andra rökdykarparet:

Mycket sällan 1 2 3 4 5 6 7 Mycket ofta

14. I vilken utsträckning uppstod missförstånd mellan rökdykarledaren och rökdykarna under övningen?

Med första rökdykarparet:

Inte alls 1 2 3 4 5 6 7 Mycket ofta

Med andra rökdykarparet:

Inte alls 1 2 3 4 5 6 7 Mycket ofta

15. I vilken utsträckning behövde rökdykarledaren be sina kollegor att förtydliga ett yttrande?

Med första rökdykarparet:

Inte alls 1 2 3 4 5 6 7 Mycket ofta

Med andra rökdykarparet:

Inte alls 1 2 3 4 5 6 7 Mycket ofta

16. I vilken utsträckning kunde rökdykarledaren utnyttja information som kom från det första rökdykarparet för att ”briefa” det andra paret?

Inte alls 1 2 3 4 5 6 7 Till fullo

17. Upplevde du att rökdykarledaren fick tillräcklig information om händelseförloppet av rökdykarna?

Från första rökdykarparet:

Inte alls 1 2 3 4 5 6 7 Definitivt

Från andra rökdykarparet:

Inte alls 1 2 3 4 5 6 7 Definitivt

18. Skatta mängden radiokommunikation från <u>första</u> rökdykarparet under övningen.

För lite 1 2 3 4 5 6 7 För mycket
Lagom

Hur mycket var relevant?

Mycket lite 1 2 3 4 5 6 7 Allt

19. Skatta mängden radiokommunikation från <u>andra</u> rökdykarparet under övningen.

För lite 1 2 3 4 5 6 7 För mycket
Lagom

Hur mycket var relevant?

Mycket lite 1 2 3 4 5 6 7 Allt

20. Skatta hur väl rökdykarledaren observerade detaljer i brandförloppet (t ex förändringar i rök, ljud etc.).

Inte alls 1 2 3 4 5 6 7 Mycket väl

21. Hur väl kunde rökdykarledaren under övningens gång göra bedömningar angående hur mycket av sin kapacitet rökdykarna hade förbrukat (hur trötta de blivit)?

Inte alls 1 2 3 4 5 6 7 Mycket väl

22. Om de fick göra om övningen, borde rökdykarledaren göra något annorlunda?

Ja □ Nej □

Om ja, vad?_____

23. Finns det något den här gruppen borde träna mer på?

Tack för din medverkan!

Annelie & Ida