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Security Modeling Technique: Visualizing Information of Security Plans

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ABSTRACT: Since the terrorist attacks of 11th September 2001 efforts are made to enhance the security standards in maritime shipping. The joint research project VESPER (improving the security of passengers on ferries) funded by the German Federal Ministry of Education and Research (BMBF) addresses among others the investigation of sea- and landside measures and processes. One of the results of the ongoing analysis phase is that the current representation of information in security plans can hardly be used for a complete real-time implementation of relevant measures in critical situations. As a result, information and design requirements to develop a Security Modeling Technique (SMT) were identified using the Applied Cognitive Work Analysis (ACWA). SMT intends to support decision making of security officers during the implementation of security levels. This contribution describes the phases of development and the resulting design concept.

1 INTRODUCTION

Since the terrorist attacks of 11th September 2001 security has become increasingly important on a world-wide scale and the possibility of terrorist attacks against seagoing ships came to the fore as well. Consequences of such events are immense. A sudden loss of a large number of human lives, destruction of material assets, environmental damages, significant disruptions of transport streams and a possible loss of confidence in maritime infrastructures can be mentioned in this context.

In order to take preventive actions against terroristic attacks, the ISPS Code (International Ship and Port Facility Security Code) was introduced in 2004 (Regulation (EC) No 725/2004) due to the efforts of the International Maritime Organization (IMO). However, the prescribed security management needs further adaptations and optimization. Against this background, the collaborative project VESPER (improving the security of passengers on ferries) was introduced, which is funded by the German Federal Ministry of Education and Research (BMBF). The project addresses the problem of terrorist threats in the maritime domain. The focus is on ferries and passenger ships operating on international routes, especially regarding roll-on roll-off processes, i.e. cargo stevedored via lorries and trains.

The purpose of the collaborative project VESPER is to systematically review the current security standard and to improve hazard prevention measures for ferries. The focus is on security during the access to the ships as well as on the shipboard and seaward measures. To guarantee security standards, there are several originated positions required by the ISPS-Code, including a Ship Security Officer (SSO) and a Port Facility Security Officer (PFSO), which are responsible for identifying threats to the ship or port security, recognizing their significance, and responding to them. Among other intentions the emphasis of VESPER is on optimization of handling processes, (especially a support for the implementation of measures for different security levels). This includes the introduction of aids for decision making in a crisis in order to minimize risks.

Within the framework of VESPER, a new modeling technique to support SSOs and PFSOs was developed, which is described in this contribution.

First, the problem of handling changes of security levels is described (chapter 2). Subsequently, a method for the design of complex systems to support effective decision making, the Applied Cognitive Work Analysis (ACWA), is introduced (chapter 3). The application of ACWA to the described work domain and the consequential outcome, the Security Modeling Technique (SMT), which supports security officers in changing security level, is described (chapter 4). Finally, results are summarized and an outlook to future work is given (chapter 5).

2 PROBLEM FORMULATION

For the purpose of analyzing and optimizing security relevant processes valid process and communication models must be constructed. So, plenty data acquisition methods have been conducted, as observations, exercise participations and interviews and discussions with experts like security officers, designated authorities, port operators, water police officers and finally document analyses like examinations of ship and port facility security plans.

In security plans measures and other information are defined for three different security levels, whereby level one is the level conducted by default. In case of a security relevant event, measures must be preventively intensified or added to a higher security level. Security officers are responsible for a proper and prompt initiation of such security level changes. The analysis of collected data showed that the current presentation of information in security plans relevant for a security level change was not suitable for a prompt and complete implementation of relevant measures in security-critical situations. Measures and information for the three defined security levels are mostly listed in wide and confusing tables and continuous texts in several text passages of a security plan.

Such a presentation of information does not permit to operate efficiently. This weak point has been confirmed by experts in subsequent discussions and by the data analysis of the accompanied exercise.

Hence, a demand for an optimized information representation and therefore information management has been identified. This should support security officers in making decisions. For this purpose a concept of a new modeling technique has been developed based on the Applied Cognitive Work Analysis (ACWA), which is introduced in the following part.

3 METHODICAL APPROACH

In order to develop a modeling technique for a support of decision making processes of security officers, first, an analysis of the work domain must be performed. The traditional task analysis methods focus on what operators do and what tasks must be fulfilled and provide descriptions of task sequences (Annett, 2004; Kirwan and Ainsworth, 1992). To account for factors like unanticipated events, dynamic changes of the situation, and real-time reactions to these changes, methods are required, which examine human cognitive processes. Cognitive Systems Engineering (CSE) is a design framework which focuses on analysis of cognitive demands in order to identify cognitive processes of operators (Crandall et al., 2006; Rasmussen et al., 1994). Methods of CSE help to understand, how experts make decisions and why they make certain decisions, what cues they need, what knowledge and strategies they use. The Applied Cognitive Work Analysis (ACWA) is a CSE approach for the analysis, design and evaluation of complex systems and interfaces. In this paper we discuss the application of ACWA for designing a modeling technique.

ACWA is a methodology for the design of a user interface for effective decision support. The process begins with the identification of the decisions that operators must make and ends with the identification of visualization and decision-aiding concepts. Thus, this methodology can be used to develop a technique to support decision maker, which is based on effective information visualization.

ACWA comprises the following process steps (Elm at al., 2003, see figure 1):

- Development of a Functional Abstraction Network (FAN) – a model to represent the functional relationships between the work domain elements
- Identification of cognitive demands which arise in the domain and need support – Cognitive Work Requirements (CWR) or decision requirements
- Identification of the Information/Relationship Requirements (IRR) for effective decision-making
- Definition of a relationship between the decision requirements and visualization concepts (how the information needs to be represented) – Representation Design Requirements (RDR)
- Implementation of representation requirements into a powerful visualization of the domain context – Presentation Design Concepts (PDC)

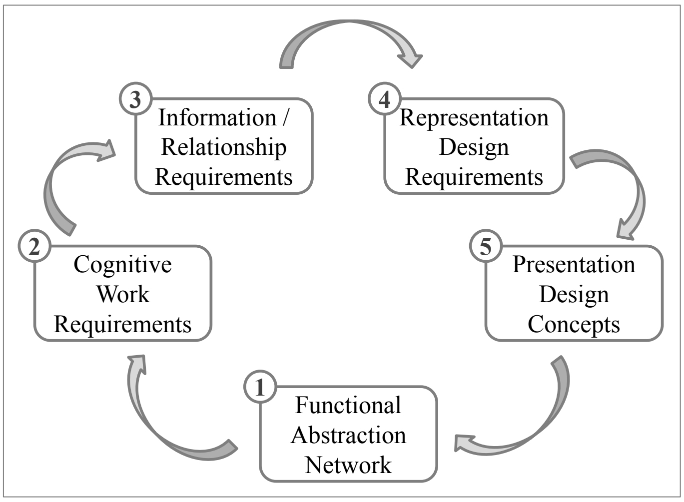

Figure 1. Iterative steps of the Applied Cognitive Work Analysis (ACWA).

The ACWA begins with a FAN which is a function-based goal-means decomposition of the domain, based on Rasmussen's representation formalism for a work domain – an abstraction hierarchy (Rasmussen, 1985), which describes human information processing. With ascending in the hierarchy the understanding for goals to achieve rises. Moving to deeper levels reveals a better understanding for the system's functions with a view to achievement of these goals. The FAN is a multi-level representation of the work domain. Each node in the network represents a goal, links represent support. Each goal has a process providing a description how to achieve this goal. Processes define supporting functions for achieving the goals in the hierarchal level above.

The FAN provides the basis for the definition of CWR or decision requirements. The CWR help to gain understanding of the goals in the work domain and enhance the decision-centred perspective. The decision requirements are to be defined for each goal node in the FAN. This ensures an understanding what decisions are to be made to achieve the goals.

Next step is to identify required information for each decision. Factors, which are essential for decision making, are identified with the CWR and therefore the context for information requirements is provided. Decision making is based upon the interpretation of information. Incorrect or incomplete information leads to wrong decisions.

Hence, the way of information presentation is very important. Appropriate information visualization can improve information processing and thus the process of decision making. The next step is to develop the decision-aiding concepts on the basis of the information requirements taking into account human perception and cognition. Display concepts which support the cognitive tasks through an appropriate visualization should be developed. At this step several different design concepts may be generated. These design concepts are still requirements and not an implementation.

The developed visualization concepts provide hypotheses about effective decision support. The next step is the development of a prototype to evaluate the effectiveness of the new system. The prototype can help to identify additional decision and information requirements for decision support which have been missing in the first steps. Thus, the ACWA approach is an iterative process (see figure 1), which leads in several steps from the analysis of the demands of the work domain to the identification of effective decision-aiding visualizations.

4 APPLYING ACWA

Subsequent it is described how the ACWA approach can be applied to determine design requirements for a security modeling technique. To gain understanding of the domain of maritime security diverse knowledge elicitation techniques have been used. Relevant documents, such as the ISPS Code, ship security plans and safety management handbooks for ships have been reviewed, interviews with masters and security officers on board of ferries have been conducted.

4.1 *Functional Abstraction Network (FAN)*

Based on collected information a FAN, which is the first step of ACWA (Figure 1), has been generated. The rectangles (Figure 2) represent goals, which are organized hierarchically, links represent supporting connections from lower-level goals to higher-level goals. The achievement of goals is described through processes (not represented in the figure).

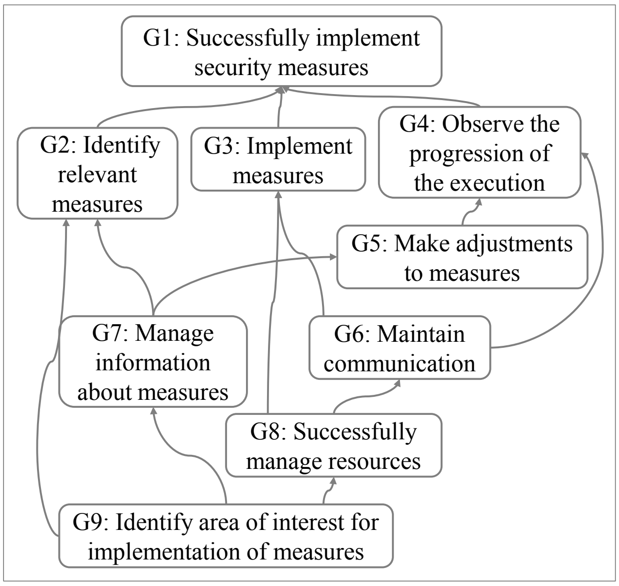

Figure 2. Functional Abstraction Network (FAN)

Table 1. Exemplary requirements for goals 7 to 9

Goal	CWR	IRR	RDR
G7	- Choose necessary information on measures - Search for additional information concerning measures - Recognize passenger procedures - …	- Indicate security levels - Indicate means/tools - Indicate allocation of means/tools to measures in different security levels - Indicate comments - Indicate belonging of comments - …	Represent security level I in green colour Represent security level II in yellow color Represent security level II in red color …
G8	- Select operator necessary to fulfill tasks - Allocate operator to area - Select technical resources necessary to fulfill tasks - Allocate technical resources necessary to fulfill tasks	- Assignment of operators to measures - Necessary means/tools - Assignment of technical resources to measures - …	- Integrate operator labels in measure shapes - Separated representation of means/tools - Connection of technical resources with appropriate measures of a security level - …
G9	- Choose relevant areas for conducting measures - …	- Information about the kind of areas (ships, port facilities, sub-areas, restricted areas, permitted areas) and their locations - Caption of areas	- Represent ships with abstracted contour - Represent port facilities with abstracted contour

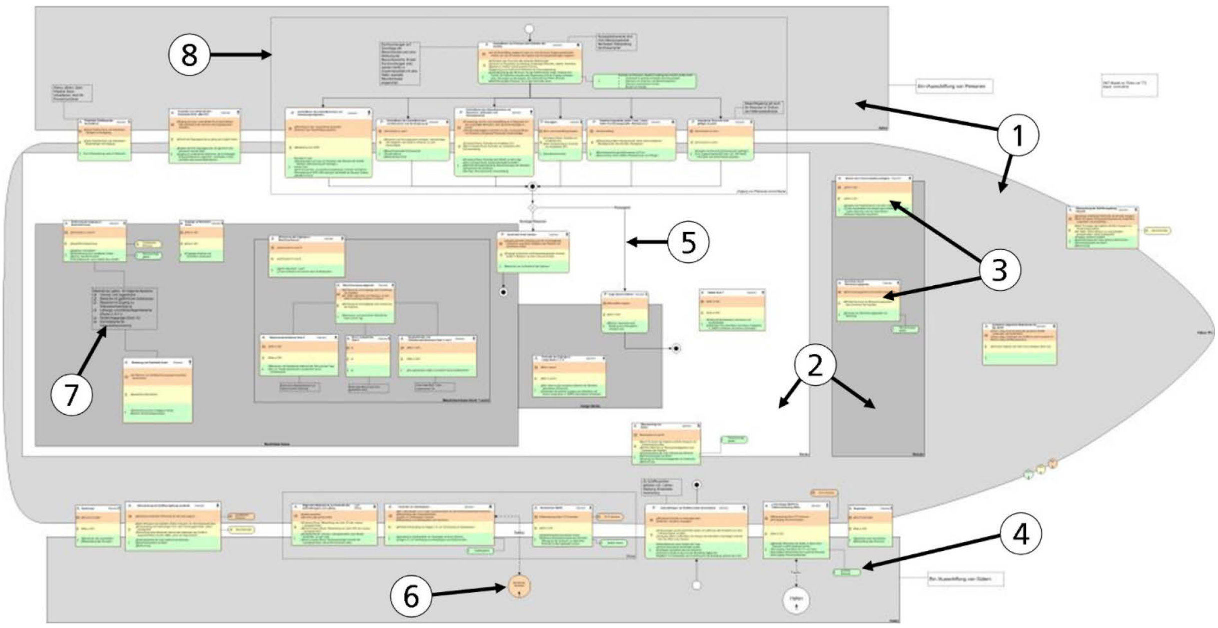

Figure 3. Exemplary SMT model of a ferry ship (numbered components are described in 4.5)

The overall goal is to successfully implement security measures from a ship security plan. For example, this goal can be described as a process as follows: Initial situation is a declared change of a security level. This induces the responsible security officer to find appropriate measures for a level change. Next, these measures have to be initiated accordingly. In the further process step the accomplishment of measures has to be controlled until all relevant measures are implemented. The overall goal of implementing security measures is supported by subordinated goals (with corresponding process descriptions). Their goals are described below.

Information about measures has to be managed, which is a supporting goal for the measure adjustments as well as the identification of relevant measures. Communication plays an important role in gaining and forwarding information. One needs to provide the information of the incident to responsible personnel on board and receive the responses.

Maintenance of communication supports the implementation and observation of execution of measures. On the other hand communication maintenance and implementation of measures are achieved through a successful management of resources. Before the initiation of countermeasures it is essential to determine whether the resources (including personnel and equipment) necessary to fulfill the measures are available or adequate. Finally, the identification of the area of interest is necessary for the implementation of measures, supporting the identification of relevant measures and the management of information as well as resources.

4.2 *Cognitive Work Requirements (CWR)*

The developed FAN is the basis for the definition of Cognitive Work Requirements (CWR) respectively decision requirements. Cognitive Work Requirements refer to the goals in the FAN. They enable comprehension of what decisions are to be made to reach the defined goals. By this means, CWR help to develop a decision-centered perspective. In the second column of Table 1 CWR are listed for the goals G7, G8 and G9 of the FAN (Figure 2). For example, for the goal "Successfully manage resources" (G8) an operator and technical resources have to be selected. In addition the operator and the technical resources have to be allocated to the relevant area.

4.3 *Information/Relationship Requirements (IRR)*

Decision making is based on interpretation of information. Incorrect or incomplete information leads to incorrect decisions. Thus, the next step of ACWA is to identify information necessary to come to decisions. In the third column of Table 1 information/relationship requirements are listed with reference to the CWR. For example, the goal "Choose relevant areas for conducting measures" (G9) requires to provide information about the kind of areas (e.g. ships and ports), as well as caption of areas.

4.4 *Representing Design Requirements (RDR)*

Next, representing design requirements (RDR) based on the IRR are defined, constituting first design ideas for an effective decision making support. The kind of information representation is of great significance since an adequate visualization of information can improve human information processing and with that the process of decision making. In the right column of table 1 RDR are listed. For example, the indication of security levels is implemented in terms of the colours green, yellow and red in order to fulfil G7: "Manage information about measures".

4.5 *Presentation Design Concepts (PDC)*

The next step of the ACWA method involves a draft of a presentation design concept and its prototypical implementation. Since ACWA is an iterative approach a prototype enables the developer to define additional requirements for the next iteration not identified in the previous one. A prototype is currently under development. Below, the presentation design concepts are introduced.

Basically, the SMT consists of five modeling categories integrated in one complex model: Modeling of areas, security levels, measures, processes and communication. In order to simplify the application of SMT, the quantity of components has been minimized. Figure 3 shows a SMT model of a ferry ship, representing information of a ship security plan. Such a model, including interfaces to adjacent port areas, allows the responsible ship security officer to get an overview of all relevant measures and adjoining information for a change of a security level. In the following we will explain the five modeling categories, mentioned above (numbers correspond to figure 3).

Modeling of areas: Fundamental to a SMT model is a modeling of areas corresponding to the real spatial conditions. Basically, there are shapes representing ships and port facilities (1) as well as shapes representing their corresponding sub-areas, namely restricted (grey) and permitted (white) areas (2). By this means, the categorization of areas concerning access authorizations is immediately evident as well as the search for location-dependent information is simplified. Particularly, the interface between ship and port which has been neglected so far, can now be taken into account by the use of the concept of area modeling.

Modeling of security levels: Each measure is allocated to one of three defined security levels. To find measures and further information for a specific security level, an intuitive and differentiating illustration is needed. Therefore, information related to security level one is coded green, to security level two yellow and to security level three red. Additionally, security levels are identifiable through Roman numerals. Apart from measures, also contact points and resources are modeled depending security levels. See Figure 4 for an activity shape representing the security levels.

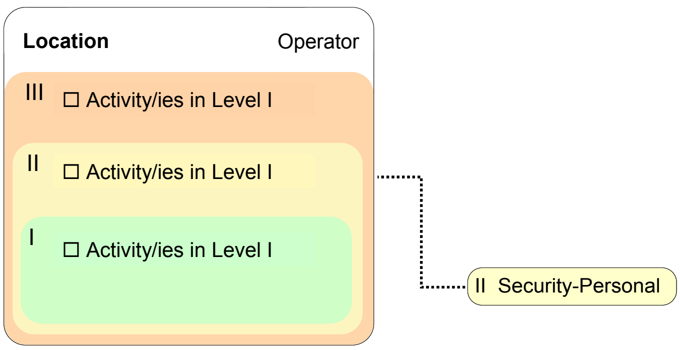

Figure 4: Activity shape

Modeling of measures: Measures are modeled in activity shapes for a certain area or the access of an area (3). An activity shape is structured in the following way (see Figure 4). At the top left is a label for the area for which the measures have to be applied. At the top right a responsible operator can be named. Apart from that the shape is divided into three colored sections listing the measures for the three security levels. Thereby, measures of higher levels substitute those of lower levels, visualized through the integration of lower level fields into higher ones. Checkboxes in front of each measure allow the marking of implemented measures.

Specific tools, equipment or additional personnel are partially necessary for a successful implementation of measures. To visualize the demand for such resources, a resource shape (4) is added to the corresponding measure (see resource shape for security level II in figure 4). By this means a resource management is maintained so that available resources can be found and allocated situation-dependently.

Process modeling: In most cases access controls for different passenger categories must be conducted in a predefined manner. In case of an occurrence of such structured procedures, concerned activity shapes can be connected by control flows and thus represent processes (5). By modeling processes the security officer deploying the model is able to quickly identify measures in chronological order and may coordinate involved measures according to the particular situation. Beginning and ending of a process are represented through distinct circles.

Communication modeling: Communication between different points is a condition for a successful implementation of measures and coordination of resources. Hence, given communication and information paths between appropriate contact points must be presented in SMT models. This is realized through contact point shapes and corresponding information flows (6).

Furthermore, there are additional components like a shape for the insertion of explanations (7) and a shape for a clustering of content-related components for clarity improvement (8).

5 SUMMARY AND FUTURE WORK

The Applied Cognitive Work Analysis (ACWA; Elm et al., 2003) is a Cognitive Systems Engineering (CSE) method which closes the gap between cognitive analysis and design existing in other methods. ACWA has been applied in the project VESPER to get a functional model of the maritime work domain of security officers. Hence, cognitive and information demands have been identified. Out of these demands visualization and design requirements have been derived. These previous steps provided the basis for the development of a presentation design concept of the security modeling technique. This technique, called ‘SMT’, enables security officers to create models of ships and port facilities. These models, used as a computer-based tool or as a large-format poster, support them in making decisions during the implementation of measures and the management of resources in the context of a security level change. Emphasis of SMT is a suitable representation of security plan information. It illustrates spatial conditions, communication, processes and area-specific measures in an integrated manner and also distinguishes the three defined security levels.

To ensure a user-friendly development of SMT models by ship, company and port facility security officers but also officers of designated authorities, an SMT editor is currently under development within the iterative development process of ACWA. The editor will also contain control functions, e.g. to guarantee the completeness of modeling measures.

The concept of SMT has been developed in close collaboration with experts in the field of maritime security (e.g. masters, security officers, ship companies, officers of designated authorities). Also the SMT editor will be evaluated and improved in intensive cooperation with these experts.

Moreover, the application of SMT and the editor shall not be limited to ferry shipping. Therefore, the concept has to be tailored to the entire international shipping. Feedback of involved experts of the maritime security domain, including representatives of German designated authorities and delegates of the European Commission, shows a concordant endorsement of the use of SMT models.

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