Visualisation Concept for Operational Parameter Settings of Dependent Processes on Naval Vessels

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INTRODUCTION

The Common Operational Picture (COP) serves as support for commanders in collaborative planning and mission execution, i.e. laid out for strategic tasks. While a common display of relevant information shared by more than one command is inevitable to successfully operate during war and OOTW (operations other than war), the picture to be displayed to the operator performing tactical tasks is important in order for him to confidently execute commands or make own decisions.

In order to foster military users in all echelons monitoring and control tasks at strategic as well as at tactical levels have to be supported. They ought to address all stages of information processing in order to enable the human operator to handle huge amount of information and to achieve high situation awareness. Furthermore, consistent functionality as well as consistent representation are required in order to meet ergonomic design criteria (*ISO 9241-10, 1996*) for either picture.

In this contribution, a hierarchical web-based interface is introduced considering as example the manual conditioning of the combat system of the frigate F124 of the German Navy. Although an explicit example is described, it is suggested to regard it as a conceptual method for designing human machine interfaces (HMIs) that are to support users in monitoring and control tasks which deal with a high amount of data in complex context.

SYSTEM COMPLEXITY AND USER SUPPORT

Parameterization of processes covered by modern software systems confers flexibility to systems operating in complex environments. Disadvantages of hard-coded systems like cost- and time-consuming software modifications no longer apply. Admittedly, complex multivariate systems or domains make high demands on the user due to the transfer of control functionality and responsibility and the task enhanced. Otherwise, the user may be supported domain specifically in several ways. Exemplary, knowledge- or rule-based planning components allow a situation dependent system configuration before a mission or specific parameters or combinations can be blocked as the situation requires.

There are many application domains that cannot be fully automated. Reasons are, for example, situations cannot be described or predicted, optimal adjustments cannot be determined neither numerically nor by simulation or the dynamic system is subject to permanent changes. In extreme cases, the user must have all degrees of freedom meaning an interaction of automated and manual adjustments is necessary. In these cases, the user interface is of great importance. Not only the actual parameter values have to be clearly

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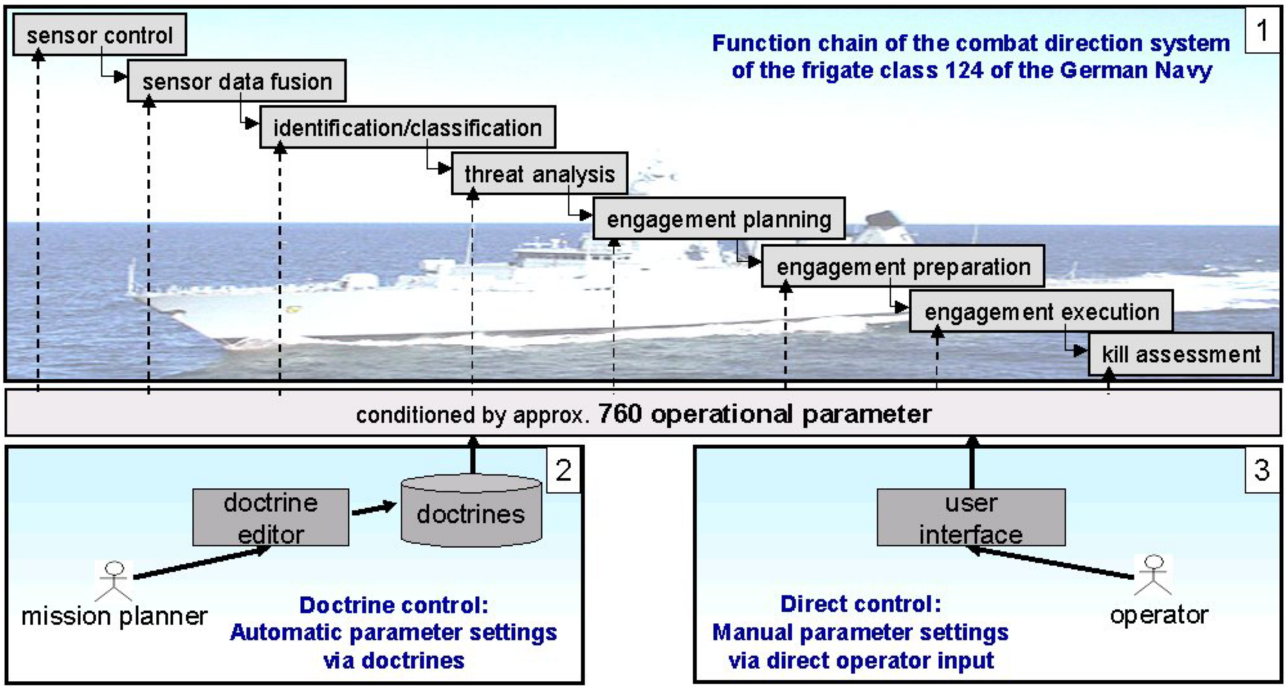
represented also the status of planning and support components in order to present and predict short-term future behavioral tendencies (system states).

Within the scope of a naval application, an user interface has been realized for a semi-automated system like the hypothetical systems described above.

VISUALISATION CONCEPT

The application domain examined is the combat direction system (CDS) of the frigate class 124 of the German Navy. This system comprises different functional processes with overall dependencies and provides degrees of freedom for the user, i.e. direct manipulation as well as automatic control are considered. A representation concept as well as an ergonomically designed user interface have been developed to be evaluated with a demonstration system and to be suggested for the real mission.

The combat direction system of the frigate class 124 comprises the dependent intertwined processes sensor control, sensor data fusion, identification/classification, threat analysis, engagement planning, engagement preparation, engagement execution and kill assessment (Picture 1, part 1). The single processes are conditioned by means of operational parameters (OPs). These are parameters that can be manually adjusted by the operator or automatically by the use of doctrines. Doctrines are special decision rules that interlink events and actions and that are ideally defined as planning tools in the forefront of a mission. In a former study, a prototypical editor for doctrines as well as a demonstrator simulating the conditioning of the combat system by the use of doctrines have been developed (*Boller, et al., 2002; Dörfel, 1998*).



Picture 1: System Conditioning by Parameter Settings.

Current research involves the formulation of a representation concept, the ergonomic representation of setting parameters and the design and development of an interactive user interface for directly adjusting the operational parameter. First, display formats of current parameter settings, orientations guides and access methods have been developed that consider the diversity of parameter values and their logical groupings. Further, representation procedures have been examined and generated for clarifying the coactions of various parameters as well as mission related dependencies. The user interface implies graphical representations of current system's adjustments as well as edit options for parameter settings and designation of critical effects.

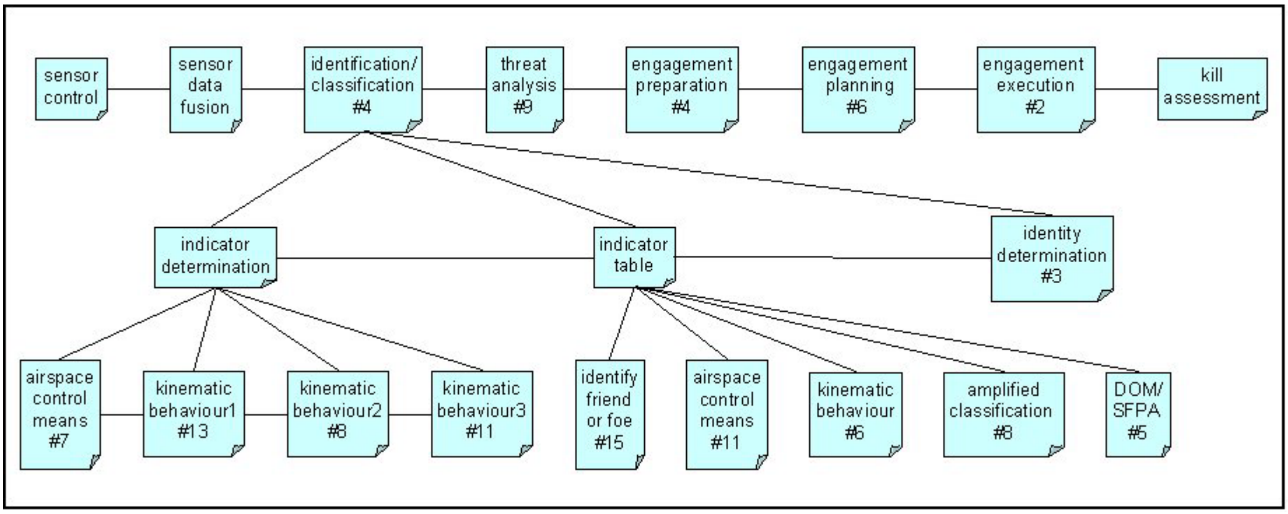
The main concern for the operator onboard is the qualitative comprehension of the state as well as behavior of the system. An optimally designed user interface ought to enable the user to visualize, e.g., which identities (IDs) tracks observed might have or must not have based on the current system configuration, in order to change adjustments appropriately, rather than to get an optimal display of a track and to backtrack why and how the system came up with a certain ID for a track. The representation of OP dependencies assists the user to rate the consequences of his adjustments. The OP dependencies structure is of high importance because of the multitude of OPs.

The CDS of the F124 has a hierarchical structure arranged in the levels segments, functional areas, capabilities and subcapabilities, whereas the OPs are located in the last. In the current implementation of the CDS the OPs are presented to the operator according to this structure. This corresponds to the technical realization and implementation specific aspects rather than to the expectations of the user.

An alternative is to assign the OPs to the elements of the function chain (Picture 1, part 1) associated with the Anti Air Warfare Area. This corresponds to the way of thinking of the operator learned during training and therefore he will be familiar with it. Consequently this mapping might be suitable to be used as the structure of a graphical user interface in terms of task oriented user guidance, fast period of vocational adjustment as well as high acceptance.

The function chain (Picture 2, upper row) represents the upmost level of the hierarchical structure of the OPs. The OPs including their dependencies as well as their effects to the whole function chain were modeled by means of a dependency graph starting with track detection up to the engagement. From that model a data flowchart has been deduced that comprises every parameter affecting the automation level. This is the basis for the content of the upmost level of the proposed structure whereas the OPs are partly aggregated for overview reasons which are itemized at lower levels. Those OPs not directly affecting the automation level are assigned to second or third level.

An example is depicted in Picture 2 representing an excerpt of the developed structure for the OPs of the identification/classification process. The second level comprises three elements whereas two have a further sublevel. There usually are dependencies between adjacent elements having the same predecessor. The #+number indicates the number of OPs assigned to each knot. For realization purposes of this structure with many branches and links a web-based implementation is indicated.



Picture 2: Dependency Structure for Operational Parameters.

A USER INTERFACE FOR THE NAVAL OPERATOR SUPPORT

The current representation of system adjustments important for military naval warfare is not rated user friendly by the German Navy. While the automation was a central concern in developing the CDS of the frigates F124 this research emphasizes the user centered design in consideration of ergonomic design criteria. Further deficiencies in the ergonomics of the current HMI are due to the fact that single components of the HMI were developed by different companies by means of restricted software tools. The present solution comprised by sequential information representation in separate windows has the disadvantages that important system adjustments are hidden and the operator is induced to a complex chain of single operations.

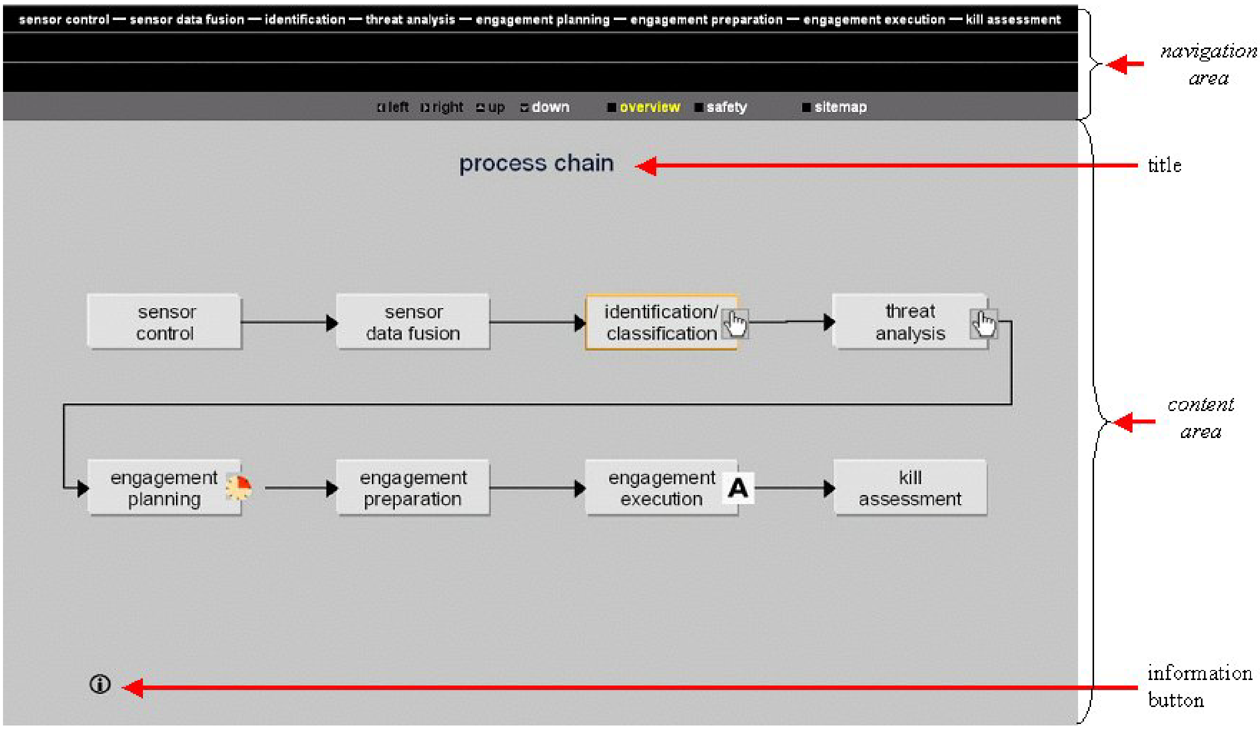
The operator has to be supported by the HMI in order to be aware of, among others, the general situation, the current state of the system, the automation level engaged and the interdependencies of the processes at any time. Further support is needed in adjustments of OPs that depend on influencing factors like the general situation, like peace, conflict or war, risk disposition and considerateness of the operator and the presence of Rules of Engagements.

The concept approach comprises a process oriented representation of operational parameter for especially clarifying the dependencies and effects of the parameter. Various hierarchical views accompanied by correspondent navigation aids provide a clear and concise representation despite of the quantity and variety of the parameter. The hierarchies display the process dependencies with an increasing detail level.

The ergonomic criterion competence support has been considered by structuring the pages as well as colouring. The pages consist of two parts: the navigation and the content areas (Picture 3).

The *navigation area* offers divers navigation possibilities. The triple-spaced navigation menu adapts according to the selection and displays the path to the actual selected page in terms of colour. The buttons *left*, *right*, *up* and *down* allow direct navigation within the developed structure of the OPs. The button *overview* yields to the overview page (Picture 3). The page *safety* provides system adjustments beyond OPs that are essential for an automatic process flow. The page *sitemap* represents all existing web pages and their cross references.

The *content area* serves for representation and editing of OPs and for representation of relevant information. There are buttons as cross references inside the content area that allow navigation to different pages without using the navigation menus. Acronyms are explained in detail by tool tips. In colouring the HMI it has been considered that it must be readable even with low lighting as, e.g., in the Combat Information Centre (CIC). Anyway, so far just the identities and indicator tendencies are coloured according to naval standard since they are the important features of the identification process.



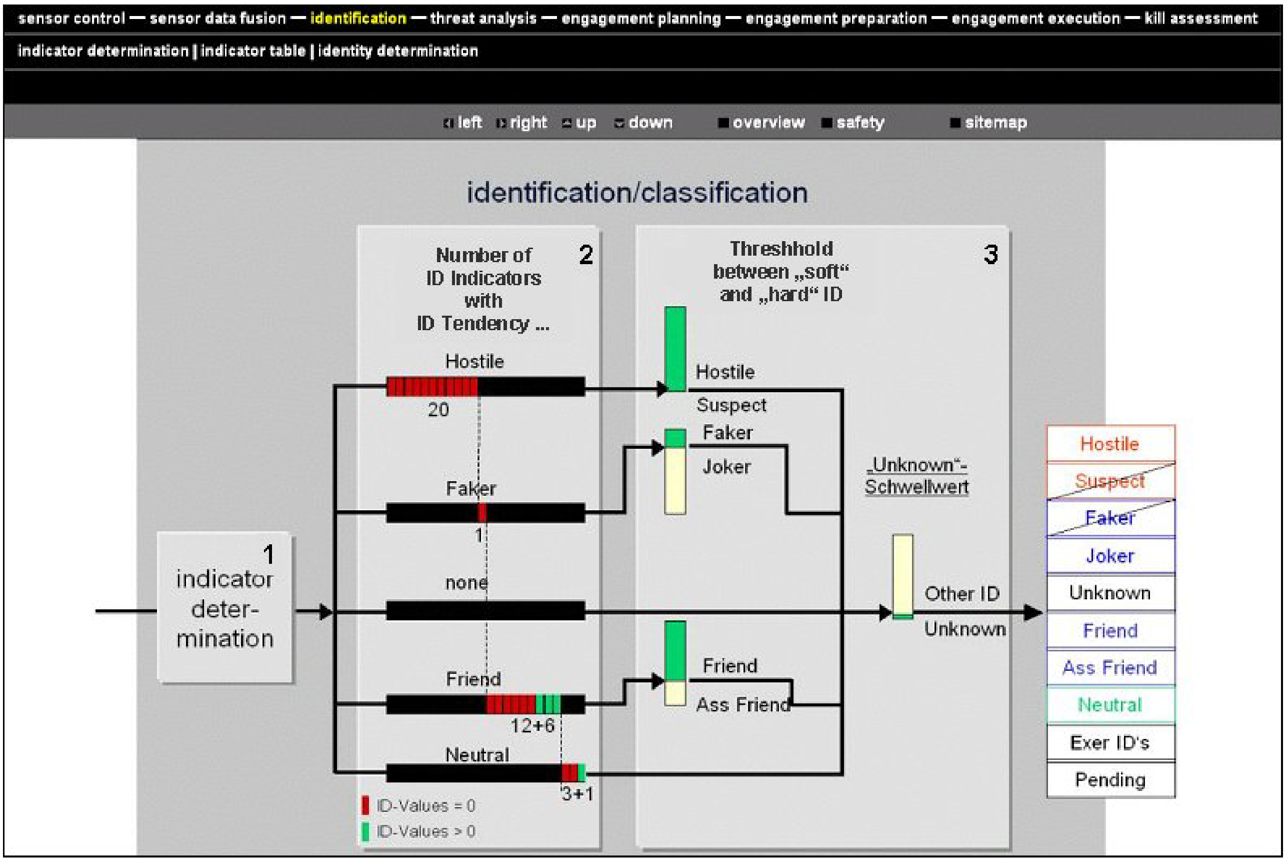
Picture 3: HMI: General Configuration (Overview Page Depicted).

An overview (upmost hierarchy level of the horizontal chain) of the total function chain informs the user regarding the rough system adjustments (automation level). Detailed information as well as adjustment chances provide level two and three. Explanation components support the user in professional appreciation und provide background information of, e.g., parameter adjustments and their dependencies. The user is guided from rough to detailed information. According to expertise and task to be performed the user navigates to relevant information either step-by-step or directly with few keystrokes (fulfilment of the ergonomic criterion: action flexibility).

The use of familiar symbols and units facilitates the user the handling of the graphical user interface. This might imply separation from internal to displayed units and labels (example: rad/degree).

The HMI has been designed according to the terminology of the application area for easy visualization of the content by the user. The ergonomic criterion task suitability is, among others, determined by the efficiency of the human computer interactions. This is warranted by the reduction of key strokes by means of, e.g., folding editing support and selective lists. Each level contains an overview to present the background story. The keyboard tokens facilitate the handling with the graphical user interface.

Picture 4 represents the identification and classification process including its output. The process follows three steps with the central emphasis of the determination of the indicator table. First, the indicators are determined (1), second, the indicator table for a track arises (2). Last, the indicator values are compared with thresholds and the identity is determined (3). The output is a list indicating tracks with specific identities to be forwarded to the subsequent process threat analysis (here: all identities except “Suspect” and "Faker"). Furthermore, the user might navigate in one of the three areas to figure out why a specific identity is not forwarded.

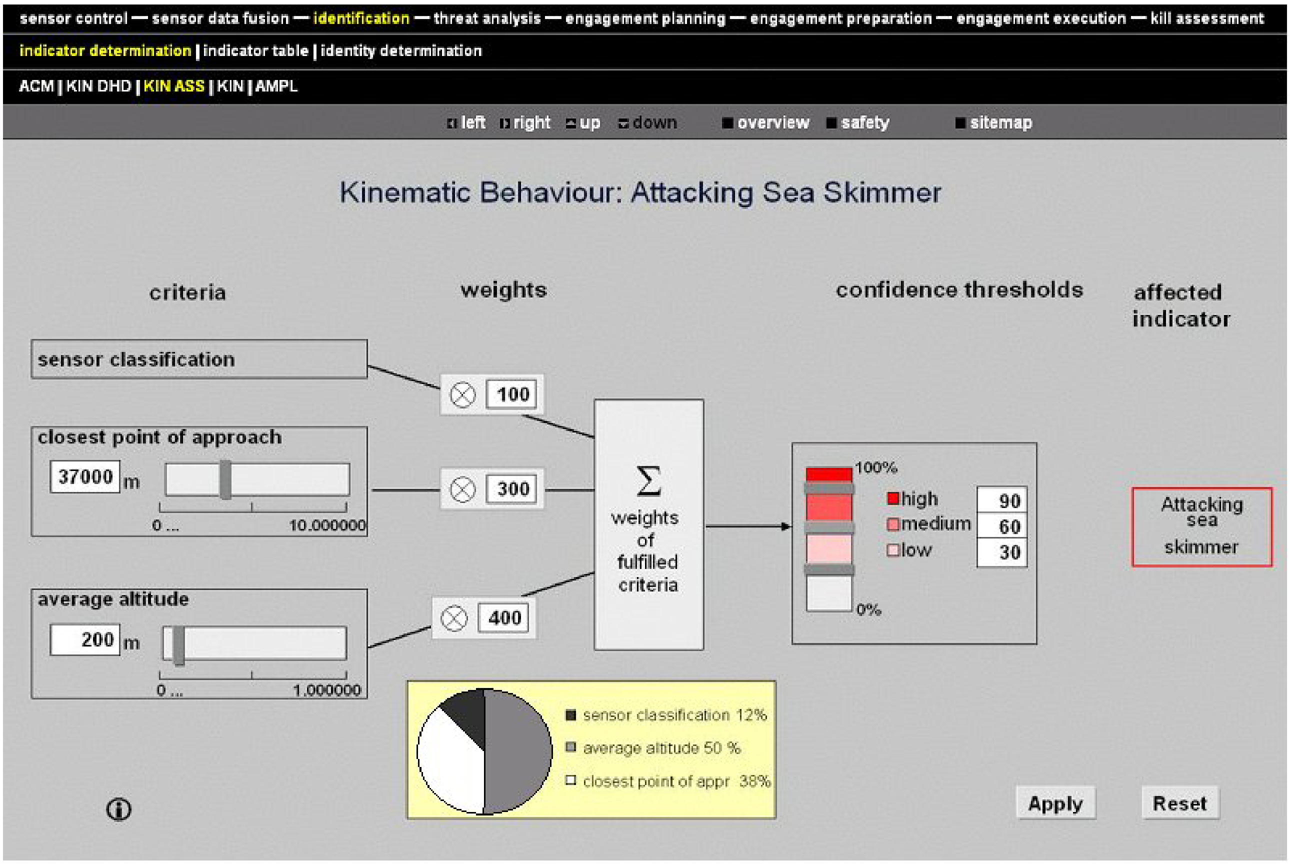


Picture 4: HMI: First Level.

Picture 5 represents the path by determining the indicator *attacking sea skimmer*[1] that belongs to the kinematics behavior indicators. Three criteria have to be determined. The first, sensor classification, is determined by the sensor. For the next two criteria sensor data are compared with values of OPs and potentially set. The sum of weights of the fulfilled criteria is balanced by the confidence thresholds low, medium und high. The result determines the confidence value of the indicator *attacking sea skimmer*. The pie chart assists the interpretation of the relations of the criteria weights.

Using rapid prototyping the user interface in extracts described above has been developed and presented to the German Navy.

[1] *Attacking Sea Skimmer* is an air track that quickly approaches in low altitude above water surface.



Picture 5: HMI: Third Level.

OUTLOOK

The current work mainly deals with the sub-process identification/classification and presents possible user interfaces to visualize and control the tasks included. Next, the prototypical interface will be implemented as an enhancement of an existing modular system for system conditioning. The complete modular system ought to cover functions like doctrine creation, doctrine evaluation, doctrine monitoring and manual conditioning (direct control) whereas tools for doctrine creation and doctrine evaluation are provided from a former study (*Boller, et al., 2002; Witt, 2003*). The whole system will be evaluated by means of a scenario that is currently being defined together with the German Navy that will include several simulated situations like different exercise types as well as real conflicts. This will incorporate a geographical information system as one component of the modular system to dynamically represent ships and tracks involved.

The contribution demonstrates how Navy officers/operators may be supported in monitoring, controlling and affecting the processes involved in the process chain starting with detecting a track through engagement execution to kill assessment. The representation concept and its prototypical realization will show the general applicability for supporting operators not constrained by the armed forces involved. Military exercises and missions ought to be assisted that imply parameter settings observed and influenced by an operator in peace or conflict situations.

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