A Predictive Task Network Model for Estimating the Effectiveness of Decision Aids for Sonar Operators

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ABSTRACT: *This project demonstrates an approach to predicting and optimizing the impact of new technologies in system re-design by using simulation to model operator-system functionality. A task network model was developed to create a real- time simulation of the tasks performed by sonar operators in building the underwater picture. This picture is created by analysing sonar data, and the process is made complex by high volumes of noise and multiple data that arrive from a variety of acoustic sources, detected at great distances by modern, sonar equipment. The task is made difficult by the fact that single acoustic sources have a complex spectrum consisting of several base frequency components and related harmonics. The task for operators is to analyse the data to determine if there is a pattern that represents the signature of a known source, thereby leading to identification of a vessel. Since the task can be highly labour intensive, automated decision aids may be of value to the operator, but their effects on performance and design trade-off decisions are not easily predicted or intuitively obvious. The task network model provided a means for developing a baseline system, against which the performance advantages of various decision aids could be evaluated. The specific improvement in performance predicted by the model for one promising aid was then validated experimentally.*

1. Introduction

This paper addresses the issue of how to evaluate the effectiveness of new tools to assist sonar operators whose task is to build an underwater picture to guide tactical decisions in the Canadian Navy. The underwater picture contains information related to the identity, position, course and speed of surface and subsurface contacts detected by acoustic sensors. Although this domain has provided the direction for the project, the methods used and results obtained generalize to more generic environments that involve the processing of large volumes of complex information under conditions high noise and uncertainty.

The specific goal of the project[1] has been to assess the effectiveness of operator aids to enhance the process of identifying vessel signatures from sonar patterns, using a task network model of the sonar domain. A simulation approach to finding practical and effective solutions to improving human-system effectiveness was chosen for a variety of reasons. First, the operational system is complex and not readily adaptable to "bench testing" new software and hardware components for evaluation

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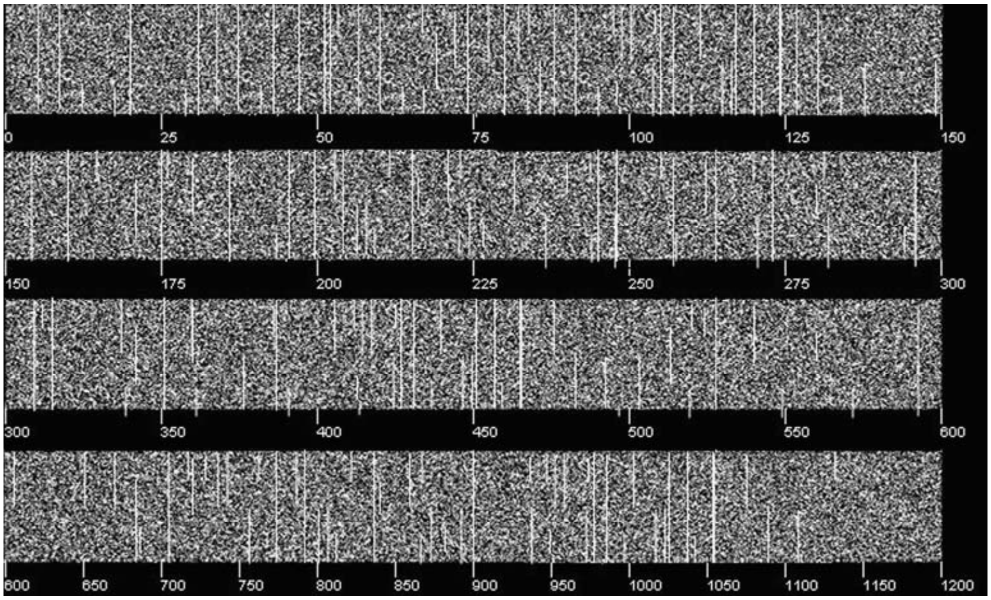
[1] This project was funded by a contract to Humansystems Incorporated® by DRDC Atlantic and DRDC Toronto and the current paper is based upon the final report by Matthews, Bos and Webb (2003).

purposes. Second, operational systems are normally deployed and not available for R&D purposes. Third, trained operators, who might be used to evaluate system improvements, are few in number and also not readily available. The simulation approach allows for the building of a baseline model that replicates the essential components of the operational environment, but then allows a variety of “what-if” questions to be addressed and provides quantitative estimates of changes in system performance and operator workload that might be anticipated by design enhancements.

Figure 1: Representative frequency/time/intensity display depicting sonar lines



1.1 The task domain

Sonar data received by acoustic sensors, often at great distances, arises from a variety of biological and mechanical sources and are affected in transmission by a variety of environmental and oceanic factors. As a result, the pattern of sonar data received from a large vessel may contain acoustic frequencies associated with many sources such as engines, shafts, propellers, generators, pumps, switches and other electromechanical devices. Each source will likely generate not only a base frequency (e.g. 60Hz) but also harmonic components at higher frequencies.

The task for the sonar operator is to distinguish among background noise the patterns of frequencies that represent likely sources and then to analyse these patterns to determine if they match the signature profile of known vessels. Information is typically provided to operators in the form of a frequency (x axis) by time (y axis) by intensity (z axis) display that updates at regular intervals with the most frequent data displayed at the bottom. Therefore, as the display updates, there will be an appearance of an upward waterfall effect. The display normally has a background level of “noise” that represents random signals arising from the underwater environment and detected by the system. Signals from sonar sources will appear on the display as vertical lines whose length corresponds to their duration and luminance to their signal strength.

A sample, representative display is shown in figure 1. As can be seen, such lines are readily detectable from the background noise, unless they are very brief in duration. The signature of a single vessel may in fact comprise anywhere between 25 and 100 lines depending upon the number of acoustic sources active, the distance to the sensor and a variety of oceanic variables. Further, the signature may not be the same fixed pattern, but oceanic conditions may cause the base frequency to appear shifted to a different frequency and may also influence the ratio of the intensity of the harmonics to the base frequency.

Thus, for the most part, there is no simple unique visual pattern that represents a vessel and hence a visual identification of the pattern alone is not feasible. This is particularly the case when several vessels are picked up by sensors and their overlapping patterns are present on the display. Thus, the task is one of serial analysis of the lines aided by a set of tools, such as a variable harmonic cursor that allows lines that are harmonically related to be determined more readily.

Complicating the process further is the fact that no single display can represent 360 degrees of coverage of the ocean. Therefore, individual sectors, or beams, (radiating from the ship responsible for the picture building) of the environment are filtered and each allocated to a given window that can be brought up on the display. Typically, the ocean may be divided into anywhere from 20 to 100 such beams, although for present purposes we have assumed full coverage with 44 beams.

Depending upon transmission conditions, distance away, the power of the source, and the overlap of the beam response patterns, a single vessel's signature may be present on a number of adjacent beams. Thus, in order to build a complete picture of the underwater environment an operator must successively step through and analyse each window associated with a beam, a process that may take hours under many operational circumstances.

A further complication is that the ship building the picture normally travels in a task group (TG) comprising five or six vessels in reasonably close proximity. Each of these vessels will generate its own acoustic pattern that will also "flood" the operator's display with lines of data. Under some circumstances these lines can number in the thousands. Further, the pattern of these lines will change over time depending upon the geospatial relationship between the vessels emitting the sounds and the vessel doing the detection, their speeds as well as the intervening oceanographic conditions.

Essentially, there are two critical picture compilation tasks to be done. The primary task is to build the underwater picture by identifying vessels of interest and their associated signatures. As part of this primary task, each line detected on a beam must be identified as belonging to one of three categories: "*known*" - a part of a target signature that is unambiguously recognised based upon information held in a knowledge database; "*unknown*" – a line that cannot be definitely associated with any known signature and "*possible*" – a line for which there is some, but inconclusive evidence, that it belongs to a known signature. The operator is required to tag each and every line on the current beam into one of these three categories, enter the information into a log and then move on to examine the data from the next beam. For simplicity, we will refer to this task subsequently as *search/id*.

The secondary critical task is to identify and eliminate from further analysis the known vessel signatures arising from the TG, thereby enhancing the ability to do the first task and the efficiency with which it can be done. This process of elimination is often referred to as "*sanitizing*" the display.

The sanitization task is essentially a top-down process, whereby the operator uses known information about target signatures of TG ships to direct the search for locating on which beams the individual lines can be found. The process ends with the operator entering into the log the locations and line components of all of the updated signatures. In reality, the way this process tends to work is that the operator looks for evidence of the individual sound sources that comprise each vessel's signature, such as acoustic lines associated with engines, shafts, propellers, generators and other electro-mechanical devices. Once all of the individual sources are found the vessel as a whole, and all of its associated lines, are then fully identified.

Because of the continuous and high work load demands associated with each of these tasks, in a typical operational environment, one operator will be assigned to build the picture (search/id) and a second to sanitize the display. When the latter operator has finished this process, she/he is then available to help out the operator building the picture.

Under some operational conditions, it would not be unusual for the sanitization process to take hours to complete, and could require the almost constant attention of one operator. The process itself does not place heavy intellectual demands on the operator, but is often referred to as "brain dead" and is known to lead to boredom and data entry errors, particularly with extended time on task.

This is a somewhat inefficient use of personnel resources, and hence the motivation for the present project was to identify possible operator aids that could assist in the sanitization process, thereby freeing up operator resources to deal with the more tactically critical task of underwater picture building.

Further, the baseline model was also seen as a way of addressing the potential operational impact of future system re-design options, including issues such as: increasing the beam resolution and number of beams, changing the number of displays and their size, color coding of information, re-assignment of operator tasks and personnel redeployment.

2. METHOD

2.1 Building the model

Using existing task analyses of navy sonar systems (Matthews, Greenley and Webb, 1991) and with the assistance of a subject matter expert who was an experienced Navy sonar trainer, critical tasks were identified that comprise the processes of the detection and identification of ships from their radiated acoustic patterns. These tasks then formed the basis for creating decision-action diagrams to represent the sequential operations performed and decisions made.

For each task, estimates were generated of the time to complete (means and variances), probability of success, consequences of, and tasks influenced by, failure and operator workload on visual, auditory, cognitive and psychomotor dimensions (VACP). VACP is an attentional demand algorithm based upon the task loading for an operator within the four separate channels and estimates the demands on human processing resources. To achieve a VACP rating, each operator task is rated with respect to the weighted task demand that appears appropriate for the specific task requirements for each of the four independent channels. Scales to assist the generation of these ratings were developed originally for an LHX mission function analysis performed by Aldrich and others (1984), for the US Army Research Institute. The scales provide a subjective rating for various levels of attentional demand. Additional work was later published by Bierbaum, Szabo, and Aldrich (1987) and provided enhanced descriptors and interval scale values.

Tasks were assigned workload ratings on a seven point scale by comparing them to normative values of the IPME workload scale, shown in full in Annex A.

2.2 Parameters of the model

The model simulated a two-operator environment in which one operator detected sonar lines of interest, analysed them and attempted to make identification from the observed pattern, while the other operator sanitized the array. Both operators entered their analysis of each line into a handwritten log that contained a number of fields of information relevant to the properties of the line.

2.3 System Hardware

In order to approximate the realities of existing sonar systems the hardware constraints were set as follows:

- Two high-resolution monitors
- Processed, narrow band, sonar data were represented on 44 beams (although in principle this number may be readily manipulated).
- Data were represented as frequency information over time. There were three display resolutions per monitor representing single, triple beam and search summary (all 44 beams) formats.
- Aural presentation of sonar data was available to operators to enable further analysis

2.4 The underwater model and sonar contacts

The detailed simulation of the complexity of the underwater environment and its interactions with the wide range of sonar data that are created by mechanical and non-mechanical sources was beyond the scope of a baseline model. Instead, the starting assumption was that a number of sonar sources, each of which has a variety of sound frequency components that arrive at the sensor, are presented on a display, or can be heard through headphones or speakers. These sonar data may come from biological or mechanical sources whose frequency characteristics may be known or unknown and are associated with a certain probability of being detected against random, background noise. Thus, the sonar database comprised a number of signal representations that corresponded to sources that, when processed by the operators, should result in identifications of non-mechanical, unknown, possible, or known. The particular frequency characteristics and the numbers and types of signal sources are described below.

2.5 Target spatial and temporal dynamics

To simplify the simulation, the baseline model did not represent the complexities of TG movement through the ocean, therefore sonar sources other than from the TG were represented on a single beam only. The model function assigned the lines of sonar data randomly to the 44 beams. While this may be unrealistic of many operational conditions it does faithfully represent the task of detecting and identifying sonar contacts that are represented on a single beam.

In order to simulate the temporal parameters of acoustic data, the data representations of the source targets were defined as having a finite, temporal lifespan that entered into the simulated underwater environment at varying points in time. In this way, the information available to the operator changed over time and, if the data were not processed before they expired, then contacts would be missed or misclassified. Once being available for processing, each target had a life span of between 200 and 600 seconds that was randomly assigned by a model function.

In order to represent the state of the system at a watch start, during the first 300 seconds of the simulation, the array was populated with lines and the search/id and sanitization tasks did not commence until this was completed.

2.6 Sonar data types

Four characteristics of sonar data were modelled as follows; their probability of occurrence is shown in parentheses:

- Source is a true target (.22)
- Source is noise (.22)
- Sonar data require the operator to wait for additional screen updates (i.e. the signal is too brief to allow analysis to occur) (.33)
- Sonar data scroll off the display before the operator has time to make an identification. (.22)

Target identification characteristics

This task could be modelled in a variety of methods depending on the level of complexity of the human processes that are to be simulated. To capture the essence of the task, and based upon Subject Matter Expert (SME) input as to what would be representative, 20 data lines on each beam (associated with a single target) were required to be present before the target could be identified. If such lines were not present, then the target would either be missed or classified as unknown. This approach was chosen to generate identification times that were consistent with the wide range of actual identification latencies that occur under operational conditions.

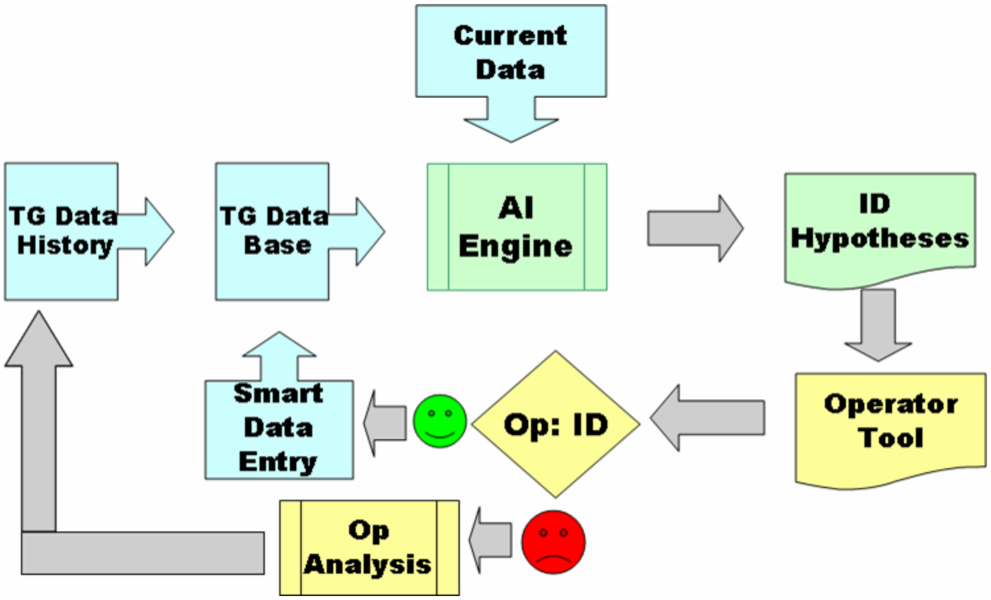
2.6 Taskgroup Data

These data result from the sensor array picking up, on a continuous basis, acoustic signals generated by noise sources on all five ships that comprised the TG. The actual number of lines that might be generated by the entire TG under operational conditions could range from the hundreds to the thousands. Based upon SME input, two values were chosen for the numbers of lines per ship to be processed, representing a low and moderately high TG “noise”. For the low load condition, there were 25 lines per ship and each ship was represented on five different beams; therefore, for the entire five ship TG there was a total of 625 lines. For the high condition there were 100 lines per ship, for a total of 2500 TG wide.

2.7 The operator model

As described above, there were two functionally separate elements of the operator model – the basic search and analysis for contacts of interest and the sanitization of the array of the known lines arising from the TG. Both operators conducted a basic search/id and one operator was additionally assigned to sanitize the array at regular intervals throughout the watch. In the standard search/id process the operator searched through the beams to detect sonar signals of interest, identify the source and log the relvant data for each line detected. One operator sequentially search up the beams from 1-44 and the other from 44-1. When sonar target signals were encountered by an operator, the search process was halted and the identification process was started by that operator on that beam. The operator resumed the search at the interrupted point, once the identification task was completed. Thus, the tasks of search and identification could not be performed in parallel by a single operator and required time-sharing.

Figure 2: Schematic representation of template assistance functionality.



When one operator interrupted the search to analyse data, the other operator continued to search until, or if, the conditions arose that required this operator also to engage in the analysis process that results in identification.

At the start of the watch (i.e. when the simulation commenced) one operator "sanitized the array" while the other operator searched. Once this sanitization process was complete, the operator also searched for contacts. The sanitisation process was required to recur several times during the simulated watch, since, as under normal operational conditions TG lines would migrate across different beams due to the changes in relative positions of the sensors and the various ships. The recurrence interval for the sanitization procedure was set at 20 minutes, based upon SME input for the conditions that were being simulated.

2.8 Running and debugging the model.

As the model ran, variables were displayed to monitor their values, and the event queue was also monitored for events waiting to be executed. The trace file was also enabled to record the time when each task began and ended. These options assisted in verifying that the model was operating as intended, and identified where changes were needed. Once the model was running smoothly, snapshots were defined to collect values of variables at specified points during model execution. These provided further validation that the model was operating correctly and identified possible problem areas.

2.9 Modeling operator tools.

Two labor-intensive, error-prone tasks of the operational environment were considered to be prime candidates for automation or operator assistance, namely the sanitization process and the logging of data. The decision was made to concentrate initially on the former process by considering the kind of tool that would help the operator to perform this process more efficiently.

To review, the current sanitization process is a top-down serial search for expected acoustic sources that comprise the signature lines of each TG ship on expected beams followed by an update of the log to reflect the actual current line data. This process is repeated for all ships until all their lines are accounted for. Obviously, this task involves a lot of back and forth checking between the log and the display, and requires the mental translation of written frequency values and beam numbers in the log into where to look, and what to look for, on the actual display. It seems feasible that a tool could be created that would use the information in the log to create a visual template, or pattern of lines, that when overlaid on the display would provide instantaneous feedback as to whether those lines were actually present on the beam.

Figure 2 depicts the functional elements and the process sequence of how the template assistance works. Data accumulated on the signature history of each ship in the task group is fed into a database. This in turn is integrated with concurrent information on the locations of ships in the TG, their speed and current oceanographic conditions using an artificial intelligence (AI) engine. The outcome of this process is an identification hypothesis that predicts each vessel's signature components and their beam location relative to the sensing source. This information is then translated into a visual template to overlay the beam(s) on which the signature is expected to be found. The nature of the overlay, as shown in Figure 3 below, is that the template pattern comprising 25 lines amplifies the luminance of the underlying sonar data when they are co-located, thereby making each signature line to appear brighter than other data lines. Also, the template extends a few pixels above and below the data area to facilitate the location of the template lines.

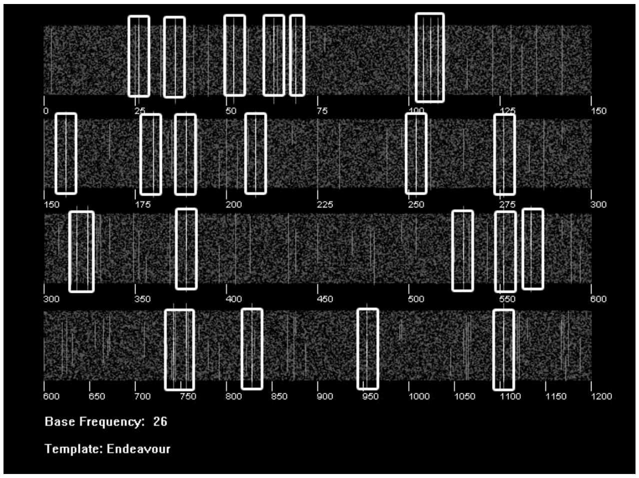


Figure 3: Sonar display with ID template overlaid

The operator uses this template to make a judgment of whether the signature is present or not and, if present, a smart data entry process captures the required information for the log. If the signature is not found, the operator analyses the line pattern found and then updates the database if the pattern is found to be at variance from the predicted identity.

Thus, from the operator's perspective, the visual analysis component of the sanitization task is greatly simplified and the human proficiency in visual pattern matching of complex features is capitalized upon.

The feedback from the Navy sonar SME on the proposed semi-auto sanitisation process was very positive and the functionality was very much in line with what he envisaged would be an optimum approach.

Accordingly, a process model was developed to analyse and simulate how such a template aid might work, the model was then run and debugged.

2.10 Model execution

Once the overall model was found to be error free it was run with 30000 data updates generated at a rate of 1 per second, thereby simulating 8.3 hours of real time operating conditions, during which time approximately three thousand lines of sonar data were entered for analysis. Ten model runs were executed for each of the conditions in which the sanitization aid was available (assisted condition) or not (baseline condition). Further, two conditions of TG load were simulated, in which each TG ship was represented by either 25 or 100 lines that required analysis and identification. These conditions were chosen to represent a range of operational conditions from moderate to high intensity based upon SME input.

3. RESULTS

Data collected from the model fell into two main categories, system performance and estimates of operator workload. For present purposes system performance data will be presented in terms of the number of times the sanitization process was completed and the total number of contacts identified and logged.

3.1 System performance

The magnitude of the performance gain in the sanitization process resulting from the template assistance is shown in Table 1. These data were the number of complete sanitizations of all 44 beams completed in the approximately eight hour run.

Run	TGship=25 lines		TGship=100 lines	
	Baseline	Assisted	Baseline	Assisted
1	4	16	1	8
2	4	17	1	8
3	4	17	1	7
4	4	17	1	10
5	4	18	1	8
6	4	18	1	8
7	4	17	1	8
8	4	17	1	8
9	4	18	1	7
10	4	17	1	8
Mean	4	17.2	1	8
SD	0	0.63	0	0.81

Table 1: Number of complete sanitizations completed for baseline and assisted conditions, where each TG ship was either 25 or 100 lines

As can be seen there is little variance across runs and the data consistently show a 4.4 times increase in sanitization rate for the low load condition and a gain of 8 times in sanitization rate for the high load condition. Because, only complete sanitizations cycles were calculated, the data for the high load condition mean that the operator had completed one full cycle and was in the process of the second cycle when the run terminated.

Given that the assisted condition produces more efficient sanitization performance, we should expect to see some impact when the resulting residual spare capacity of the sanitizing operator is redirected to the search/id task. The following table addresses this issue and shows the number of contacts classified for each of the test conditions. Clearly, there is a gain in performance for both load conditions and statistical analysis of these data showed that for both the 25 line (t=13.38, df=18, p<.01) and 100 line (t=14.47, df=18, p<.01) conditions there was a significant increase in the number of contacts logged when the task of TG sanitization was template assisted.

Run	TGship=25 lines		TGship=100 lines	
	Baseline	Assisted	Baseline	Assisted
1	36	53	33	41
2	35	50	35	40
3	36	49	34	40
4	42	50	35	42
5	39	53	34	39
6	39	49	32	42
7	37	50	35	40
8	37	51	34	42
9	36	48	32	40
10	36	56	34	43
Mean	37.3	50.9	33.8	40.9
Delta		36.5%		21%
SD	2.11	2.42	1.135	1.29

Table 2: Number of contacts correctly identified for baseline and assisted conditions, where each TG ship was either 25 or 100 lines.

3.2 Operator Workload

Mean workload scores for each operator on each of the workload dimensions for each of the experimental conditions were computed based upon the individual 35225 values computed by the IPME model during each of the 10 runs. The means of the ten runs were then calculated and the ensuing data are shown in Figure 4. Data are presented for the two sanitization conditions in which the number of lines per TG ship was either 25 or 100 per beam.

Statistical analysis of the data was conducted using two-factor (baseline/assisted and number of lines per TG ship) analysis of variance (ANOVA). Where necessary, supplemental comparisons were made using t-tests. It was decided that it would not be appropriate to combine all of the individual workload measures into a single multivariate analysis of variance, in view of the fact that the auditory workload scores showed opposite effects to the other measures and that the separate workload indices are theoretically uncorrelated.

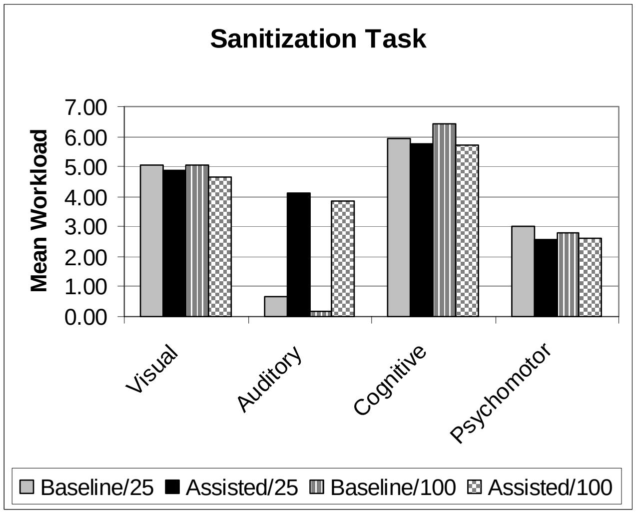


Figure 4: Mean workload ratings as a function of test condition

For the both TG conditions, there seems to be a small trend for lower workload ratings in the assisted condition for visual, cognitive and psychomotor components, and a reverse trend for the auditory workload component. The effect of the number of TG lines to be analysed was not consistent. For all workload measures except the cognitive (where the reverse was true), workload was slightly higher in the 25 line condition. However, these effects are quite small, typically of the order of less than .1 on the 7-point workload scale, but are statistically significant because of the small variance between simulation runs. The significant interactions for visual and cognitive workload scores reflected a larger effect of the template assistance under the 100 line condition, compared with the 25 line condition. This difference was in the opposite direction, however, for the psychomotor scores.

4. DISCUSSION

The results of the simulation show that the impact of adopting a smart, visual template to assist the sanitize process has a significant effect on the speed with which this process can be executed. As a result, more sanitization cycles can be performed in a watch and there is additional residual capacity created, such that the "operator" performing the sanitization task is able to work on the search/id task thereby improving the overall rate of identifications for that task also.

The results showed minimal impact on mean predicted operator workload across a test run (i.e. watch period) resulting from the use of the template for the sanitization task. This may be for two reasons. First, the numbers entered into the model may not have been valid (being simply based upon the IPME normative values). Second, any small differences in workload between baseline and assisted conditions for the actual sanitization process may have been masked by the use of session-wide average ratings, which include all of the other tasks executed, when there was available time, beyond the visual process of making the template match.

While the results of the simulation clearly pointed to the potential value of the aid, there was some concern of their validity from two perspectives. First, while the model function parameters for known sonar tasks were based upon recommendations from an experienced SME, the values used to estimate task performance with the template were derived from an analysis and estimation from published human factors data for similar task contexts, together with input derived from the experience of the human factors team. Second, the values used for the workload for each task were based upon the IPME scale values, and there may some issues with how well such values generalize to other task situations.

Accordingly, it was decided that there should be an attempt to assess the validity of the modelling and simulation results by collecting human performance data with real operators performing the sanitization task under baseline and assisted conditions. The critical data would comprise both performance effectiveness (in terms of throughput or sanitization rate) as well as perceived workload for each task component.

Two problems immediately presented themselves in considering the validation approach. First, existing sonar systems do not provide the kind of flexibility required to serve as an experimental testbed. Second, access to trained sonar operators in sufficient numbers to generate a statistically acceptable design was virtually impossible.

The obvious solution therefore was to build a simple simulation of the sonar sanitization task that would allow us to train non-Navy personnel to the required standard of proficiency and then conduct the validation study with such personnel.

Space limitations for the present paper preclude the possibility of describing the validation experiment in sufficient detail. However, the results can be summarized by stating that the human performance data fell within the range predicted by the model and that the predicted gain in performance due to the provision of the decision aiding tool was generally supported by the data obtained. In contrast, workload ratings generated in real time by the participants in the study were consistently lower than predicted by the model for both baseline and assisted conditions.

Thus, we were able to conclude generally that the modelling approach provided a reliable and valid method for estimating the effectiveness of a decision aid on system performance. Further, the creation of a comprehensive baseline model will allow quantifiable estimates to be made on the effectiveness of other future system re-design options,

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Annex A: Table showing workload descriptors

Ordinal rating (W/Index)	Interval rating (VACP)	Descriptor
VISUAL		
1	1	Register/Detect (Detect Occurrence of Image)
2	3.7	Discriminate (Detect Visual Difference)
3	4	Inspect/Check (Discrete Inspection/Static Condition)
4	5	Locate/Align (Selective Orientation)
5	5.1	Track/Follow (Maintain Orientation)
6	5.9	Read (Symbol)
7	7	Scan/Search/Monitor (Continuous/Serial Inspection, Multiple Conditions)
AUDITORY		
1	1	Detect/Register Sound (Detect Occurrence of Sound)
2	2	Orient to Sound (General Orientation/Attention)
3	4.2	Orient to Sound (Selective Orientation/Attention)
4	4.3	Verify Auditory Feedback (Detect Occurrence of Anticipated Sound)
5	4.9	Interpret Semantic Content (Speech)
6	6.6	Discriminate Sound Characteristics (Detect Auditory Differences)
7	7.0	Interpret Sound Patterns
COGNITIVE		
1	1.0	Automatic (Simple Association)
2	1.2	Alternative Selection
3	3.7	Sign/Signal Recognition
4	4.6	Evaluation/Judgment (Consider single Aspect)
5	5.3	Encoding/Decoding, Recall
6	6.8	Evaluation/Judgment (Consider Several Aspects)
7	7.0	Estimation, Calculation, Conversion
PSYCHOMOTOR		
1	1.0	Speech
2	2.2	Discrete Actuation (Button, Toggle, Trigger)
3	2.6	Continuous Adjustive (Flight Control, Sensor Control)
4	4.6	Manipulative
5	5.8	Discrete Adjustive (Rotary, Vertical Thumbwheel, Lever position)
6	6.5	Symbolic Production (Writing)
7	7	Serial Discrete Manipulation (Keyboard Entries)