Electronic Performance Support Onboard Ship

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Casualty investigation statistics show that nearly 80% of shipping accidents are caused by human error. Thus, a major task facing the shipping industry is to improve performance and decision-making on board ships and ashore. However, the nature of the industry makes this difficult, namely the reduced staffing and demanding sailing schedules, equipment with similar functions but significantly different operation and technology, a high turnover of personnel, insufficient time for training and familiarisation with equipment, and frequent transfers between ships with different machinery. The concept of an electronic performance support system (EPSS) is proposed as a strategy to improve task performance under similar situations. We are talking about marine engineers who have already been trained but still need help when performing tasks to avoid costly mistakes. After a ship's personnel has been suitably trained in marine training institute which includes class room lessons, practical training in workshop and exposure to generic computer based training onboard ship to gain practical skills and under pinning knowledge, the focus shifts to performance of tasks for safe and efficient operation of vessel. At this stage task specific, machine specific and ship specific EPSS provides job support using "best practice" to reduce performance time and prevent human error. In other words "do it right first time". The paper examines the EPSS approach and justifies its necessity for use on board ships. A framework for designing an EPSS is described along with an example.

KEY WORDS
EPSS; task; training; performance; support; multimedia

INTRODUCTION

The knowledge requirements of seafarers' jobs are growing rapidly. Changes in shipboard technologies and in the nature and organization of shipboard work in general have fuelled the demand for officers and engineers equipped with solid literacy, hard and soft skills. Despite the maritime schools producing certified & competent mariners, performance gaps remain on board that can be addressed by an electronic performance support system (EPSS).

Developments in computer technology are rapidly transforming the way in which information is distributed and retrieved; knowledge and expertise is stored and acquired; and skills are learnt and transferred. Engineering training and skills development must make the most of these developments in order to meet the challenges of handling complex plants and equipment (Banerji and Bhandari, 1995).

For example, suppose you were responsible for operating an air compressor and it started to sound unusual. You could use the EPSS to call up typical sounds that have been recorded, such as motor bearings, crankcase, L.P and H.P valves, and match the unusual sound to the recorded sound files. Once you identified the sound, you could determine the problem and begin corrective action. The knowledge stored in the EPSS could be used to repair the problem. It could show you video clips of how to disassemble the equipment and replace the malfunctioning part. The system could also be used to order a new part from the supplier.

The advent of multimedia technology has meant that many new approaches to instructional and information delivery can be implemented. These resources can be amalgamated in a suitable way to create an EPSS. This approach is now gaining much attention and is being used in a variety of industrial situations (Banerji, 1995). This paper first describes the basic tenants of the EPSS approach. The particular requirements of the shipping industry are examined, and finally, it describes the EPSS development work that has been done by SMA.

SHIPBOARD ENVIRONMENT

Our rationale for proposing performance support intervention for the marine industry is based upon studies of shipping accidents. For example, "casualty investigation statistics show that as much as 80% of all accidents can be traced back to procedural reasons, whereas only 20% are directly related to technical failures. In other words 80% of all maritime accidents are caused by substandard acts and about 20% by substandard conditions" (Dombey, 1994). Acknowledging the gravity of this finding, the International Chamber of Shipping observes - "while statistical analyses suggest that around 80% of all shipping accidents are caused by human error, the underlying truth is that act or omission of human beings plays some part in virtually every accident, including those where structural or equipment failure may be the immediate cause" (Card, 1996).

The management and operation of a ship is specialised and complex and is further complicated by: (a) reduced staffing and demanding sailing schedules; (b) numerous equipment performing similar functions but differing significantly in operation and technology; (c) high turnover of personnel; (d) insufficient time for training and familiarisation with equipment; and (e) frequent transfers between ships with different machinery. Thus, the International Maritime Organisation (IMO) and national regulatory bodies have introduced standards, conventions and international rules for safety and pollution control including SOLAS (Safety of Life at Sea), MARPOL 78 (Marine Pollution), STCW 95 (Standards for Training and Watchkeeping 95), International Safety Management (ISM) and Load Line.

The STCW 95, which came into force in February 1997, is a comprehensive education and training convention implemented to improve standards of competence of management, operational and support staff worldwide. It defines and covers three essential areas:

(a) The responsibility of shipping companies to employ competent sea-going personnel and to provide continuous training;
(b) Uniform competency standards; and
(c) Issuance of certificates to sea-going personnel who meet the required competency standards.

Indeed there has been much infusion of and improvements in technology on board ships in order to reduce the incidence as well as severity of maritime accidents. Shipping companies have installed generic computer-based training and assessment programs in their training centres and onboard ships. However, these improvements become ineffective if crews are not trained to react properly when emergencies occur. Regulating the technical aspects of marine operation can only partly achieve the objectives of safer ship operation. Personnel competence is a critical factor in the safe and efficient operation of ships. From what has been described above, three major support functions for the marine industry (after the crew has undergone conventional training) can be identified: (1) task-oriented specific skills training; (2) on-the-job training and advice; (3) assessment and monitoring of competency. All three can be achieved by implementing EPSS. An engineer needs support beyond STCW.

RATIONALE FOR PERFORMANCE SUPPORT

The challenge for ship owners, operators, machinery manufacturers and training institutes is to equip the ship's crew with the basic engineering skills for the correct operation and maintenance of equipment onboard the ships. Even if the ship's crew has received prior training and briefing in these tasks in a shore establishment, they may have difficulty recalling the knowledge at the time of carrying out the tasks. Although they would have access to traditional hardcopy machinery manuals, these contain a large amount of text and drawings making them difficult to plough through to find the necessary information.

Skill Loss- How quickly are skills forgotten?

Shipping companies spend considerable resources to provide shore-based and/or shipboard training to their staff. However, because of the time elapsed between the training and the actual execution of the task, a seafarer may be unable to fully recall all the information necessary for performing the task.

“We all need support from time to time. How many times do you wish some guru would look over your shoulder when you are doing something new on your computer? Think of a performance support system as an expert helping you to do your job better”. (Jim Martin).

TIME TAKEN TO PERFORM A TASK

In order to understand the rationale for EPSS, it is necessary to consider the factors influencing the time taken to perform a task within a given application domain. In general, the total time taken to perform a task (T_{task}) depends on two basic factors - first, the time to find a method (T_{method}), and second, the time for the actual execution of the task ($T_{execute}$). That is, $T_{task} = T_{method} + T_{execute}$

One of the most important features of an EPSS is its ability to minimise the overall task performance time. In order to fulfil this requirement, it is necessary to identify which of the factors in the above equation has the largest effect in limiting performance. The EPSS can then be designed to remove these limitations.

There are four basic ways by which a person could obtain a method to fulfil a task: recall, search, learn, and devise. Conventionally these are done with the help of paper-based instruction manuals and checklists. However, a multimedia computer can be used as an EPSS to minimise T_{method} for each of these approaches. If the method that is needed for a particular task is one which is frequently used then it is likely to be recalled easily - thereby giving a minimal T_{method}. However, if it has to be searched for (either in one’s long-term memory or within an instruction manual, company procedures or an online system), then (T_{method}) is likely to increase substantially. If a method cannot be recalled or found by searching, then an appropriate one will have to be learned. If a suitable method for handling a task does not exist then an appropriate one will need to be devised; this situation can lead to maximal values of T_{method}.

Similar arguments to those presented above apply in the case of executing a task. If the task is executed by a human, then skill enhancement (through training) and providing a good work environment might help to reduce the time taken to execute a task ($T_{execute}$) and hence overall performance time.

For example a third engineer on a ship has to overhaul a “Sperre Model HV1/140A air compressor” which he may not have worked on before. He has skill and experience in maintenance and overhauling of “Tanabe air compressor” from his previous ship. Then machine specific “EPSS of Sperre Model HV1/140A air compressor” can provide task performance support.

EPSS is “just-in-time refresher” for a skilled marine engineer, who has had prior training. It is like providing machinery instruction manual before starting a task, but multimedia EPSS is better than text based information. However EPSS will not reduce the need for minimum staff level nor the basic skill requirement to carry out a task.

Therefore besides reducing task performance time, the other important functions of a performance support system are reduction of operational error and improving the quality of task performance. (Banerji,1995, Barker, 1996).

PERFORMANCE VERSUS LEARNING FOCUS

The primary focus of EPSS is to provide support for performing a task (procedures and processes), finding information in databases (experience capture, trouble shooting) presenting information in alternate forms (video, audio, text, image, data) for easy understanding to trained personnel who still need support.

As a secondary function EPSS can also have a learning focus in for example a junior wants to familiarise with a machinery or equipment he will be working on under his senior so that he can assist better and knows what is going on during overhauling or maintenance. In this case EPSS is not meant to replace customary maritime training as required by STCW.

Thirdly we can also add assessment with feedback to test the understanding of the user and clarify doubts. But it is stressed that primary focus is on performance support and this objective should not get diluted.

EPSS DESIGN MODEL

Nowadays, in most modern workplaces, computers are used for decision-making, task performance and also planning, thereby replacing many manual methods. The work is done neither by people nor by computers alone but by 'man-computer' systems (Singleton, 1974). In these situations computers act as a powerful tool by providing an interface to the basic job tasks that are involved. Humans and computers thus tend to work cooperatively and symbiotically (Licklider, 1960) - combining the advantages of the powers of each in order to achieve more effective job performance. This in fact forms the basis for the current growth of interest in EPSS. The concern of an EPSS is effective human-task interaction in which the computer provides an interface to various job tasks and becomes an effective aid in achieving efficient task performance. An EPSS is thus defined as *'a human-computer activity system that is able to manipulate large amounts of task related information in order to provide both a problem solving capability as well as learning opportunities to augment human performance in a job task by providing information and concepts in either a linear or a non-linear way, as and when they are required by a user'* (Banerji, 1995).

When designing an EPSS, it is important to understand those aspects of human performance that most often need to be augmented. Annett (1983) suggested that the knowledge-based component of a job-specific skill is most vulnerable to forgetting and that this often constitutes the major part of skill loss. He identified five major types of forgetting: facts, tasks, mis-remembering, rusty skills, and absent-mindedness. None of these types of forgetting are necessarily complete. For example, people can recall a forgotten fact minutes or days later - or almost immediately when given a suitable cue.

One of the design goals of an EPSS is to come to the aid of a seafarer who experiences these types of forgetting. An EPSS should also help employees to adapt quickly and to learn new processes or changes in procedures and practices.

The focus of the EPSS model is on supporting task performance through an array of computer-based support tools providing guidance, expert advice, training, information, and reference material. The EPSS facility makes these available at the point of need while performing a particular job as defined by the just-in-time (JIT) paradigm. Some of the different types of functionality that an EPSS should attempt to provide are listed below:

- Online manuals, including user's guides, reference materials, engineering drawings, and schematics with search and browse capabilities;
- Risk assessment and safety instructions;
- Operation and maintenance procedures and best practices;
- Knowledge capture and guidance in performing a particular task;
- Multimedia database interface that allows retrieval of various types of media to support actions;
- Trouble-shooting guidance; and
- Underpinning knowledge related to the equipment or tasks.

INTERFACE DESIGN

"I will not use this program." This is the user reaction that software developers fear the most. Research shows that 86% of people who decide not to use a recently purchased/installed software program do so because of the interface. A key element of performance support is the way in which the user communicates with the computer and vice versa. Great effort needs to be devoted to the design of performance support interfaces. - Dr.Beatriz Beltran

The interface functionality requirements for an EPSS are:

- The screen architecture (structure) must remain consistent within an application;
- The screen elements should be easy to find and use;
- "Clutter" must be minimized in screen real-state use;
- Menus and data-input forms should be easy to use; and
- The functions of buttons and other controls should be communicated by their appearance.

EPSS uses a new set of interface design principles (Fig.1) - "performance-centred design" for professionals in the human computer interface design community, as compared to "user-centred interface design" in conventional computer-based training programs.

User-centred designs found in learning packages onboard ships are for structured learning and organized for e.g. as Lesson 1, 2, 3, and so forth.

User-centred design Performance-centred design

Fig.1 Comparison of interface design

Performance-centred design (PCD) is about human performance, not system performance. PCD infuses tools with knowledge, structures tasks, and enables performers to achieve the required level of performance as quickly as possible - at the very most, within a day - with minimum support from other people.

Software that is designed around performance is intuitive to its users and enables them to perform their normal work with obvious gains in speed and efficiency.

On the other hand EPSS is not a cure all for performance problems. It requires persons are properly trained, have skills, tools, environment and attitude for successful task performance.

BENEFITS OF EPSS

There are several benefits of a computer-based EPSS:

- Just in time training reduces knowledge loss due to time lapse between knowledge acquisition and its application. This results in improved performance with less number of errors;
- Ready access to the latest information and procedures, and reduced information overload for personnel;
- Expert and consistent advice is always available;
- Reduction in training costs if refresher courses are required for personnel;
- Customised tools to support work functions, spare parts control, record of maintenance history, and learning. An EPSS can create a seamless mix of learning and performance; and
- Experience-capture facility can create a database of problems and resulting solutions for trouble-shooting and maintenance of machinery, which would be of use to both a novice and an experienced engineer.

EPSS DEVELOPED BY SMA

Singapore Maritime Academy has developed a number of EPSS' for use in its workshops and on board ships. Some are briefly described below.

The Turbochargers EPSS, (Fig. 2) provides support in the form of safety, disassembly, inspection, assembly, spares, tools, troubleshooting, worksheets, e-Manual and tips.

Fig.2 Turbocharger EPSS for VTR 500

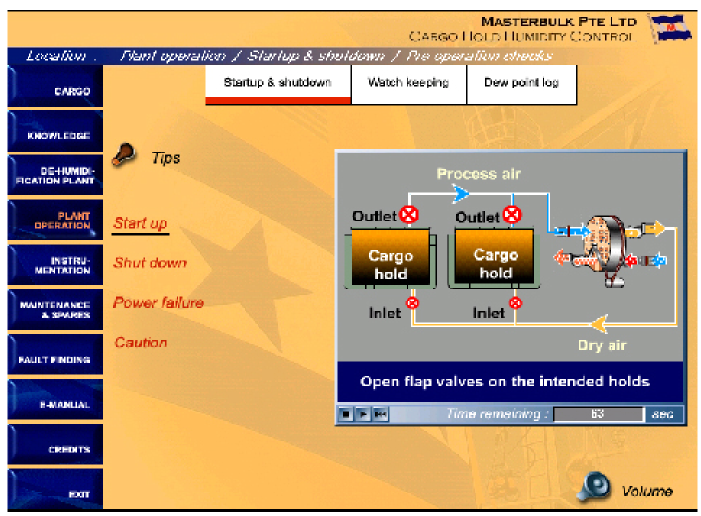

Fig.3 Cargo Hold Humidity Control EPSS

The Cargo Hold Humidity Control EPSS (Fig.3) provides support on preventing moisture damage to cargo. It provides information on the types of moisture-sensitive cargo, how condensation takes place, use of dehumidifier, dew point simulator, dew point log, tips, watchkeeping, troubleshooting and maintenance.

CONCLUSION

Seafarers get frequent transferred between ships and are exposed to machineries of different makes and models. Carrying out maintenance and operation of machinery without total familiarity can result in human error and costly damage. In order to bring them up to the task quickly, classroom or conventional computer-based training which they have undergone under STCW, should be supplemented with an electronic performance support system (EPSS). EPSS is used while performing important tasks related to safe and efficient ship operation. With an EPSS, seafarers can access the computer for help with their tasks as and when they need to. This help can be in form of graphics, text, simulation, and audio, i.e. multimedia. Support can be in the form of consistent information on operation, maintenance, troubleshooting, repair, parts data, diagnostic routines, or other pertinent data. It will reduce the time taken to execute a task.

The EPSS empowers the user to take charge, and improves the performance of the individual and the group. Who couldn't use help like that! This is the job of an electronic performance support system.

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DISCUSSION

Question

At the U.S. Merchant Marine Academies, they use simulators to aid their classroom training. At SUNY Maritime College, they use a Kongsberg simulator. Is there a way that EPSS could be integrated into these simulators, and the two systems perhaps share an interface so that a new 3rd assistant engineer could have a familiarity and a comfort level with the equipment when he goes aboard a ship with an EPSS?

Reply

As far as simulator is concerned, to enhance the learning experience it can be integrated with complete replica of an actual engine room. We have that at SMA. Another approach is to make 3D walk through model of an engine room complete with machineries, and integrate with simulator. In the 3D mode an engineer can do basic tasks such as watch keeping, start and stop machineries adding some realism to the training. But this will be generic training. Onboard ship, new 3rd assistant engineer will require support here and there while doing specialised tasks all the way to the rank of Chief Engineer.

One comes across many different makes and models of machines and equipment on different ships. It is difficult for a trained engineer to master all the technology and hence requires support to prevent costly mistakes. In context of this paper, Electronic Performance Support System is task specific, machine or equipment specific. For example it can reside in a notebook PC or even a PDA. The engineer keeps the notebook PC near the machine he is going to work on and refers to it as and when required while carrying out task such as operation, maintenance or trouble shooting. The interface of EPSS has "performance-centred design" so that a new 3rd assistant engineer would be comfortable when using an EPSS.

Question

How would an EPSS interface with the company database? What are the logistics of this happening? Would it be a regularly scheduled synchronization? Only when the ship is in-port? Would this happen by way of a satellite linkage? How could a Chief Engineer share his problems with the fleet? Would the EPSS have a recording station so that a ship experiencing a machinery problem could advise the other ships in the fleet to watch for similar problems?

Reply

A concept of an EPSS has been presented. It can be a simple CDROM based “equipment specific EPSS” located on ship or technologically advanced EPSS system, residing in company’s head office servers. In the latter case “sister ships” (with identical machineries) can share the information and experiences. Ships connected to head office via “always on satellite broad band connection” or able to “synchronise” with head office database will be at an advantage compared to those with a simple CDROM based EPSS. Yes technology is there by which a Chief Engineer can upload not only photographs but unusual noises from a machine when sending in his report. This information can then be shared by other Chief Engineers and juniors.