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GMDSS Operability: The Operator-Equipment Interface

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In this paper, the operability of the GMDSS is studied to identify those aspects that are hindering its successful use. Particular emphasis is placed upon the operator-equipment interface within the working environment of the ship's bridge. The results of a relevant survey, based on the opinion of recently G.O. certified navigation officers, indicate that – despite the automation in GMDSS and the resulting reduction of the human factor – there is a definite need to improve the knowledge-based proficiency of the operator. The current design of the system, and the increasing workload on the ship's bridge, constitute the main drawbacks to operability and dictate the requirement for improved knowledge and hence improved certification and refresher training for operators.

KEY WORDS

1. GMDSS. 2. Safety. 3. Automation. 4. Human Factors.

1. INTRODUCTION. Since the beginning of the last century, following the fundamental changes introduced in marine communications after the *Titanic* disaster in 1912, marine radio has helped to save tens of thousands of lives at sea, and become the key element in marine search and rescue. The original distress system mainly relied upon ship-to-ship communication depending on highly trained radio officers (or operators), who sent a distress message using Morse Code (or radiotelephone) in the hope that another ship or shore station would hear the call and respond. In the early 1970s, IMO concluded that it was necessary to modernize the maritime radio distress system that had been adopted by the then new SOLAS Convention. After almost 80 years of development, marine distress alerting still relied on a human being sitting in front of a receiver to maintain a listening watch on the distress channel. Despite many technological innovations in maritime communications over the decades, few had been adopted as part of the international safety system even though other provisions of SOLAS have been updated and modernized on several occasions. The 1979 Search and Rescue (SAR) Convention was convened to define a global system for responding to emergencies, and the concept of the Global Maritime Distress and Safety System (GMDSS) was introduced to provide SAR with efficient communication support, i.e. by moving the emphasis from ship-ship alerting to automated ship-shore alerting to Rescue Coordination Centres (RCC). In 1988, Chapter IV of SOLAS was completely revised to incorporate amendments to introduce the GMDSS. These amendments came into force on 1 February 1992 with a phase-in period to 1 February 1999 and marked the arrival of the GMDSS as a revolution in marine communications, mainly through its ability to automate a ship's radio distress alerting function, thus removing the requirement for manual watch-

keeping on the distress channel. Furthermore, the GMDSS is not just for emergency and distress messages, but also for all types of existing ship-to-ship and ship-to-shore routine communications. From 1 February 1999, the GMDSS became mandatory for all passenger ships carrying more than 12 passengers operated on international voyages and all cargo ships of 300 gross tons and above. Although the GMDSS does allow national administrations to dispense with the onboard radio officer, compliant ships must have GMDSS qualified personnel, in accordance with Standards of Training, Certification and Watchkeeping (STCW) Chapter IV requirements. Hence, shipboard radio watches are now being maintained by GMDSS qualified navigation officers, as a part of their standard bridge watch routine.

It is widely acknowledged that the GMDSS works and has already saved many lives (IMO, 1999). However, as any new system with highly technical and functional content, the GMDSS is not problem-free, and it seems that its implementation difficulties quickly became its operational drawbacks. So far, research on GMDSS effectiveness ranges from problems associated with false alerting (MCA, 1998), signal interference (Czajkowski, 1995) and items of equipment (Patterson *et al*., 1999; Diaz, 1998; Cooper, 1997), to those of training (Hellsaa, 1997). Apart from this effort, which has produced valuable information in revealing specific problems of the GMDSS and led to specific measures (MSC, 1998; IMO, 1995), it is considered appropriate to place the discussion of GMDSS effectiveness within the framework of the influence of human factors on safety and performance (Goulielmos, 1996; Clench, 1995) and the emerging relationship between the onboard crew and bridge technology (Goulielmos *et al*., 1997). This depicts the notion that the GMDSS operator is a component of the system in an organised array of components designed to accomplish a particular objective according to plan. In terms of shipping safety, the successful impact of the irreversible trend of a man-depleted and technology-filled bridge will always depend upon the careful optimisation of the interface between the man and the technology he uses (Tzannatos, 1995).

2. GMDSS: THE SYSTEM.

2.1. *The Equipment*. Within the framework of the available terrestrial and satellite technology, the set of equipment employed by the GMDSS is determined by its functional requirements. The GMDSS is called upon to perform nine basic functions amongst which the safety-related transmissions prevail. The functional core of the system is to provide rapid alerting mainly of shore-based rescue and communications authorities in the event of an emergency, as well as alerting vessels in the immediate vicinity and providing improved means of locating survivors. One feature of the GMDSS replaces the traditional method of establishing communications by voice calling with an automated method, applicable to Medium Frequency (MF), High Frequency (HF) and Very High Frequency (VHF) radios, called Digital Selective Calling (DSC). Other elements of the GMDSS include the INMARSAT A, B, and C maritime satellite systems; the coastal NAVTEX and INMARSAT SafetyNet broadcast systems which provide weather and maritime safety information; Emergency Position Indicating Radio Beacons (EPIRB) used for distress alerting and locating; and radar transponders (SART) on life rafts, which are used in the location of survivors. The ship-shore design philosophy of the GMDSS, and the different range and service limitations of the above mentioned equipment, have dictated the division of the world's oceans into four areas, namely A1, A2, A3 and A4 in a representation of sea regions increasingly distant from the coast. Equipment requirements vary according to the area the ship is trading to or through, and they are also cumulative in nature. Therefore, the minimum carriage requirement (for an A1 ship) numbers nine items of equipment, whereas the list extends to a minimum of 13 items for most of the ocean-going vessels. Furthermore, the duplication of equipment constitutes one of the methods for meeting the regulation requirement for GMDSS availability, the other too being sea- and shore-based maintenance.

2.2. *The Operator*. GMDSS ships must have certified personnel according to the following GMDSS qualifications:

(a) First Class Radio-Electronic Certificate;
(b) Second Class Radio-Electronic Certificate; and
(c) GMDSS General Operator's Certificate.

With respect to the General Operator's Certificate (G.O.C.), the training requirements involve an exhaustive list of items ranging from radio theory and practice to regulations and the candidate's qualification subject to physical competence and other general or miscellaneous conditions. The G.O.C. is a non-technical operator qualification designed for navigation officers. Throughout the world, accredited providers run G.O. certification courses of about 70 hours (spread over 10 to 14 days). In some countries, Greece inclusive, the public nautical schools offer G.O. courses of around 125 hours and hence they typically provide more thorough training. The Radio-Electronic Certificates are technical qualifications designed for ship's radio-electronic officers, who sail on GMDSS ships that employ the method of at-sea maintenance towards meeting the regulation requirement for GMDSS availability.

3. OPERABILITY.

3.1. *General*. The areas that hinder the effectiveness of the GMDSS are inevitably relevant to those that degrade its operability. From the preceding descriptions it is evident that the GMDSS operator is called upon to perform numerous important (and most frequently life-saving) functions using an extensive set of sophisticated equipment, in various combinations depending on the sea area through which the ship is sailing. In any industrial application, an operating load of this nature is sufficient to establish the operator as the most essential component of the system. For safety-critical applications in high-risk operations, such as the case of GMDSS in shipping, the operator is predominantly at the core of the system.

With reference to the working environment of a ship's bridge, the arrival of the GMDSS reinforced the current trend of lower manning and increased technology, through the introduction of further job integration (merging of navigation and radio duties) and equipment concentration respectively. This trend inevitably leads to the risk of an excessive multi-tasking workload, since the level of automation involved in the GMDSS is partly relevant to its functional requirements. The concept of bridge management that requires a navigation officer to perform numerous and different tasks at the same time is generally ineffective. For example, cargo handling and passage through restricted waters are routine activities that demand the full attention of the navigation officer; whereas, in the case of emergencies, prioritised response and concentration on tasks is vital. Besides, the code of International Safety Management (ISM) requirements for shipboard response to emergencies dictate a clear distinction of roles and duties for navigation officers, as well as the adherence to specific action plans. Finally, with respect to the working environment, it must be mentioned that on most ships (some post-GMDSS ships exempted) the workload and multi-tasking intensity is exaggerated by the bridge layout. More specifically, in these older ships, the GMDSS is situated either at the old radio room or in the wheelhouse out of direct contact and sight.

The design of the GMDSS is an important operability factor. GMDSS technology is an example of poor design, which acts as a barrier to effective operation. More specifically, although the criticality of the system deserves more attention to practical design, it appears that many GMDSS manufacturers did not concentrate on the development of a sound ergonomic system. Most designs provide evidence that the end product is merely an assembly of individual units (radio equipment) and controls (buttons, switches, etc). The absence of an integrated design philosophy has often increased the complexity of the system through the unnecessary duplication of controls and the failure to optimise its interfacing performance. Furthermore, the GMDSS design differs significantly amongst the various manufacturers in terms of layout and appearance. Upon embarkation, personnel required to operate GMDSS are often faced with the task of having to use a different set of equipment to the one on which they were certified or have previously worked, thus increasing familiarisation time and the risk of operational errors.

Finally, GMDSS ineffectiveness is often attributed to a lack of operator proficiency, i.e. his knowledge, experience and skill in operating the system. However, it is important to realise that the proficiency of personnel must be mainly knowledge-based. All operators must possess a sound operating knowledge prior to going onboard, because:

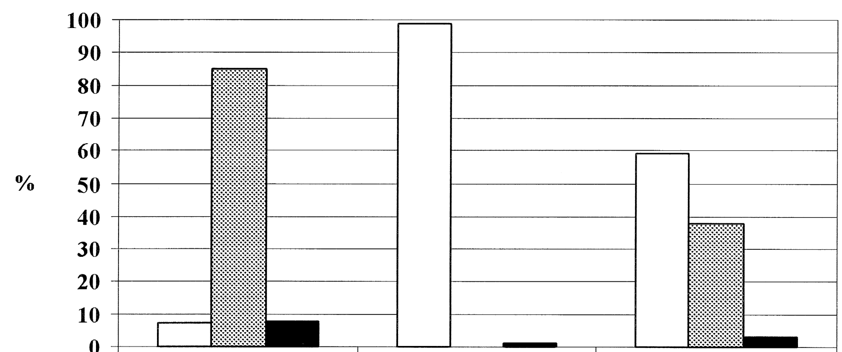
(a) The sophistication of the system is not compatible with skill development;
(b) The criticality of the system makes no allowance for 'trial-and-error'; and
(c) The workload of the bridge limits the ability for onboard training.

Since the operating knowledge of the GMDSS ought to be derived from certification training, it is this area where most attention must be concentrated in order to ensure the system's effectiveness. However, subject to the adherence of the relevant guidance regarding time and content, training adequacy depends upon the equipment itself. The earlier comments about the lack of good and standardised design apply here too. There is an urgent need for a GMDSS design that will also act as a successful simulator for subsequent effective operation.

3.2. *Survey*. Most of the preceding remarks with relevance to the operational ineffectiveness of the GMDSS are reflected in the results of a recent survey involving 100 recently G.O. certified navigation officers. The survey was based upon responses to a questionnaire to which the officers were asked to answer with maximum sincerity subject to a commitment of confidentiality.

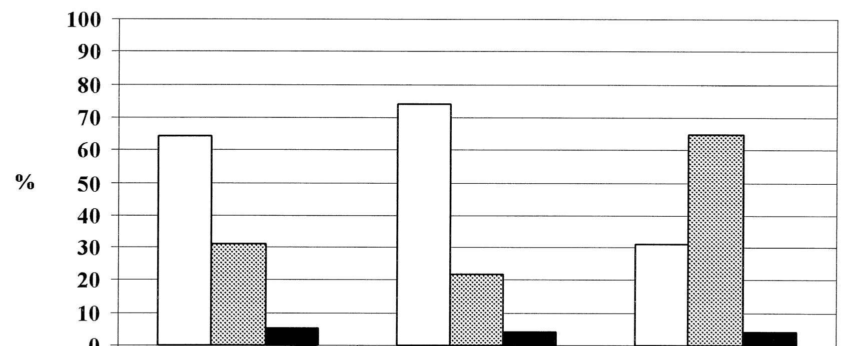
The theoretical and practical training received was assessed as satisfactory by 85% and 77% of the officers, respectively. The dissatisfied officers found the theoretical and practical training inadequate mainly in terms of content (7%) and time (9%), respectively. This is an encouraging picture because it provides clear evidence of a successful standard of training, although there is room for further improvement.

The impact on management of the ship's bridge by the introduction of the GMDSS is presented in Figure 1. It is important to note that a significant number of officers (85%) consider the withdrawal of the radio officer unnecessary and almost all of them



	WAS R.O.'S WITHDRAWAL NECESSARY?	IS THE B.O.'S WORKLOAD INCREASED?	IS THE INFLUENCE OF THE H.F. REDUCED?
□ YES	7	99	59
▨ NO	85	0	38
■ N/A	8	1	3

Figure 1. Impact of GMDSS on management of the ship's bridge.



	IS THE GMDSS EFFECTIVE AS A SYSTEM?	IS THE GMDSS OPERATIONALLY COMPLEX?	IS THE GMDSS DESIGN SATISFACTORY?
□ YES	64	74	31
▨ NO	31	22	65
■ N/A	5	4	4

Figure 2. Effectiveness of GMDSS.

(99 %) believe that the navigation officer's workload has increased. Although, these two statements are interrelated, they both provide a clear indication of the demanding nature of the new (post-GMDSS) working environment on a ship's bridge. For 59 % of the officers, the reduction in the influence of the human factor could merely reflect the fact that the GMDSS makes the bridge technology more intensive. Therefore, this

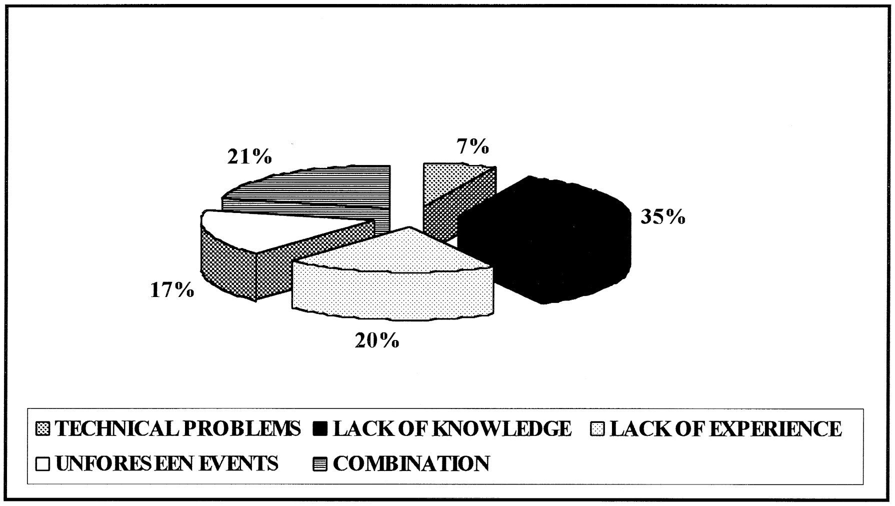


Figure 3. What are the reasons for false alerts?

statement, in conjunction with that for bridge workload and the radio officer's withdrawal, reveals the increasing importance of the human factor and becomes consistent with the view for its increasing influence stated by the 38% of the officers.

The GMDSS is considered effective by 64% of the officers, although an equal number finds the design of the system unsatisfactory and an even higher number (74%) classifies it as operationally complex (Figure 2). Overall the statements made here do not reveal a high degree of operator confidence in the system and imply the need for considerable improvement. Since much of the operational complexity derives from poor design, the latter becomes the main target for improvement.

As shown in Figure 3, false alerts were attributed to the operator by 55% of the officers, whereas the influence of technical problems was considered minimum (7%). For the operator's contribution to false alerting, lack of knowledge was clearly selected as the dominant cause (35%). Furthermore, the combination of reasons (21%) places more emphasis upon the operator and his knowledge. Overall, these statements highlight further the need to provide particular attention to GMDSS training.

Finally, 81% of the officers consider themselves capable of operating the system (Figure 4). If, apart from all the previously stated drawbacks, the self-confidence of the operator plays a positive role in GMDSS effectiveness, this statement conveys a very optimistic and encouraging message.

4. PROPOSALS. A possible avenue for alleviating the higher workload produced by the introduction of the GMDSS upon the ship's bridge is offered through the regulation requirement for GMDSS availability. The implication of the relevant regulation is that most GMDSS ships have the option of rejecting the method of at sea maintenance, in favour of equipment duplication and/or shore-based maintenance, depending on the area of their operation. Availability of a duplicate system means that, if it can be suitably designed to operate in a simulation mode when required, practice and training could be very effectively undertaken

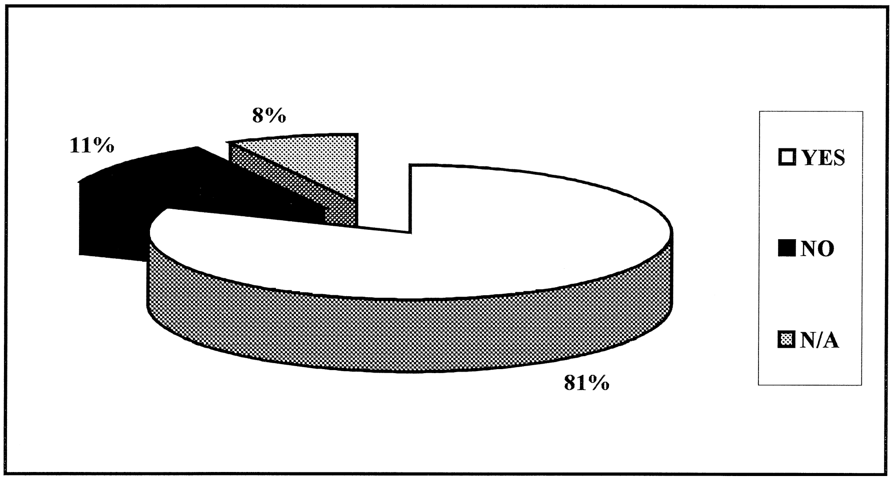


Figure 4. Do you consider yourself capable of operating the system?

onboard. However, it is important to note that shipping operators are rapidly acknowledging the fact that, in the emerging era of the 'all-electronic-ship', the GMDSS is only the tip of the iceberg. The practicalities of the modern shipping environment suggest that an electronics officer, whose job will be the maintenance and, where necessary, the repair of sophisticated equipment onboard, is something many ships could not afford to be without. From a practical and economical point of view, the electronic officer may offer a more favourable solution through the merging of the onboard duties in the area of ship electrics and electronics. An electronic officer onboard opens a way of putting the radio officer back on the ship's bridge, since a G.O. certification of the electronics officer will qualify him also as a GMDSS operator.

With respect to the design problems of the GMDSS, it is important to mention that much of the work carried out by IMO in the development of the GMDSS was based on the SAR Convention of 1979, which in turn took into account technology as it then existed. From then on, policy-making and regulation followed technological evolution with inevitable delay, and the rapid progress in communications technology has lead to the current version of GMDSS becoming outdated. Therefore, it is necessary to rethink and redesign an integrated modular system to produce a standardised GMDSS solution for training and operations that has the ability to incorporate the very frequent technical updates that lie ahead quickly and efficiently. Contrary to 'equipment-scale' measures and small item improvements (such as the standardisation of the distress button), the design problems of the GMDSS require 'system-scale' solutions to ensure sustainable operability in an era of rapidly evolving technology.

Finally, assuming the availability of a properly designed GMDSS simulator, improved certification training can be achieved through the allocation of more time to practice and the provision of more 'equipment-targeted' theory. Workload permitting, and subject to the ability to run the system in a safe training mode, onboard practice and training becomes a favourable proposal towards enhancing the operability of the GMDSS.

5. CONCLUSION.

Evidence has been obtained in support of the conclusion that all future efforts towards the promotion of GMDSS operability and hence of its effectiveness should embrace the following statements:

(a) The influence of the human factor upon shipping safety is indisputable, but the promotion of safety is more likely to come through the improvement of the operator's presence within the system rather than introducing more technology towards his replacement.
(b) In the introduction of onboard technology, scale, timing and input rate are important, because they affect operability.
(c) Ships are run by people and not by devices and equipment. The latter are intended to aid the running of the ship, and they can only do so if they are operationally friendly, otherwise they can be potentially dangerous.

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