NAVAL SHIP SAFETY MANAGEMENT

by Commander Doug O'Reilly

INTRODUCTION

The development of ship safety practices, like many aspects of the marine industry, has been evolutionary. Typically, major advances were made in response to a significant incident. The sinking of the TITANIC led to the first International Convention for Safety of Life at Sea (SOLAS) in 1913. The convention required that ships have enough lifeboat capacity to accommodate all crew and passengers and that ships maintain a 24-hour radio watch. Several LIBERTY class ships, built by the US Navy between 1941 and 1945, sank alongside as a result of brittle fracture. These incidents led to advances in ship construction practice.[1] The HMCS KOOTENAY gearbox explosion in 1957, which resulted in the loss of a number of sailors, led to improved gearbox maintenance procedures and shipboard fire-fighting practices.

Despite decades of evolutionary development, there were still significant problems in ship safety well into the 1990s. Hundreds of commercial ships were lost at sea each year. The figure topped at over 400 ships in 1986.[2] Problems in ship safety were not limited to commercial ships. The US Navy, Royal Navy, and Royal Australian Navy have all experienced problems that indicate fundamental shortcomings in their safety arrangements. The US Navy alone loses enough sailors in one year to operate a SPRUANCE class destroyer.[3]

Motivated by growing public concern and in recognition of fundamental problems, several navies and commercial shipping organizations have recently taken steps to improve ship safety. Based on public inquiries and other studies, it was found that the traditional approach to safety, based on evolutionary development, lacks coherent management attributes and cannot, by modern standards, provide adequate assurances of safety. To address the problem, formal ship safety management systems were established. These safety management systems employ proactive, modern risk management methods that cover all aspects of engineering and operations, and provide through-life assurances of safety from ship concept to disposal.

Canadian naval safety arrangements are based on a traditional approach to ship safety. These arrangements suffer from the same fundamental shortcomings discussed above. Despite a good safety record, incidents and near misses continue to occur, indicating that these arrangements do not provide adequate assurances of safety. The Canadian Navy must adopt a formal safety management system.

This paper will demonstrate that Canadian naval safety arrangements do not provide a level of assurance that is appropriate for current times. It will show that traditional safety arrangements, the basis for Canadian naval arrangements, are inherently deficient. The paper will provide evidence, based on recent incidents, that there are systemic problems in Canadian naval safety arrangements. The paper will present an alternative approach to safety management that provides adequate assurances of safety for a reasonable investment.

DEFICIENCIES IN TRADITIONAL SAFETY ARRANGEMENTS

The United Kingdom (UK) Health and Safety Executive has clearly demonstrated that there are inherent problems in traditional safety arrangements. The Health and Safety Executive assessment is based on a number of disasters that resulted in significant losses of life in the 1970s and 1980s. Notable incidents include the capsizal of the Herald of Free Enterprise,[4] the Piper Alpha disaster,[5] the fire at Kings Cross railway station,[6] and the Clapham junction railway accident.[7] Public inquiries into these disasters indicated a need for a fundamental change in the approach to safety. Prior to these incidents, the focus of safety had been on the prevention of design and material failures. Rigid codes and prescriptive regulation controlled these potential failures. The public inquiries found that the traditional approach to safety paid inadequate attention to operational issues, that the management of safety was poor, and that prescriptive regulation was inappropriate for modern times.[8]

The findings of the inquiries highlight the lack of a comprehensive, through-life view of safety. As indicated above, the focus on safety was on the physical design and material state of an installation. The inquiries found that approximately 80% of the fail-ures were, in fact, attributed to operational failings. A thorough analysis of the incidents indicated that most of these accidents were not caused by the simple “human failings of the operator”.[9] Contributing factors includ-ed inadequate training, inappropriate operational procedures, a lack of emergency procedures and poor ergonomic design. To ad-dress these deficiencies, the inquiries emphasized the need for formal safety management systems. Those systems must be based on a comprehensive approach to safety that covers all aspects of design, operations and maintenance through the life of the facility.[10]

Other contributing factors to the incidents, such as poor communications and inadequate deficiency rectification procedures, indicated that the management of safety at an organizational level was poor. J.T. Stansfeld, a Senior Principal Surveyor with Lloyd’s Register, summed up the situation by stating, “In a sense almost all accidents are due to management failings: if they had seen that the plant was better designed or maintained, that the training or instructions were better or that previous violations were not ignored, the accident would not have occurred.”[11] The inquiries also found that management attitudes and organizational systems had a significant influence on safety arrangements. To be effective, safety arrangements must be es-tablished with a view to "managing" safety. The management system must be cross-or-ganizational and integral to the organization's function. A genuine concern for safety must be embedded into the corporate culture.[12]

The third finding of the inquiries was that detailed, prescriptive regulations are not appropriate to modern technology. The development of prescriptive regulations tends to be reactive, based on lessons learned or past practice. They tend not to be forward-looking and do not readily adapt to technical or functional change. As a consequence, prescriptive regulations can inadvertently become obsolete. The prescriptive approach encourages a "compliance culture" that is fo-cused on complying with the word of the rule rather than its intent. There is little incentive to understand the rule, its inherent assumptions and its objectives, and to optimize safe-ty and economy by the best possible means. The prescriptive approach is not amenable to regulating management structure and corporate communications, which were found to be major contributing factors to accidents. In addition to the safety implications, prescriptive regulations have cost-related and operational implications because they provide limited scope to be innovative or take full advan-tage of technological advances. Based on the findings of the inquiries, J.T. Stansfeld concluded that the prescriptive approach to safety "is not appropriate to modern technol-ogy and that self-regulation by industry itself, exercising a more open end duty of care, is likely to be more satisfactory."[13]

THE "GOAL SETTING" APPROACH TO SAFETY

To address the issues raised in the public inquiries, the UK Health and Safety Executive introduced legislation that emphasized the use of modern safety regulations based on a "goal setting" approach. This ap-proach sets out high-level objectives or performance standards. The primary objective is based on the principle that safety risk must be as low as reasonably possible (ALARP). This principle "means not only that risk must be reduced to a tolerable level, but also a fur-ther reduction must be achieved, provided that the penalties [in terms of time, money and trouble] are not disproportionate to the improvement gained."[14] To achieve the objective, this "goal setting" approach uses modern risk management methods to demonstrate that all foreseeable hazards have been identified and that appropriate controls have been provided.

As a significant departure from the prescriptive approach, the "goal setting" approach places the burden of proof on the own-er. This has two advantages. Firstly, the reg-ulatory body is less reliant on prescriptive regulations, which are susceptible to obsolescence and evoke a limited "compliant" response from the owner. The owner must work with a clean slate for each new installation and demonstrate that all safety issues have been identified and addressed. Second-ly, the owner has much greater flexibility in demonstrating compliance. The owner is free to use novel or innovative solutions as long as they are supported by the appropriate anal-ysis and/or testing.[15]

The key components of the "goal set-ting" approach are the Safety Culture and the Safety Case concepts. Safety Culture is de-fined by the International Atomic Energy Ag-ency as "that assembly of characteristics and attitudes in organizations and individuals which establishes, as an overriding priority, that safety issues receive the attention warranted by their significance."[16] In practical terms, safety culture involves a complete and coherent framework of safety policies, organ-izational structure and practices to manage safety throughout an organization. Integral to the framework is a continuous improvement process, which possesses attributes similar to modern quality management processes. The process clearly defines how assurances of safety will be achieved, taking into account regulatory requirements and the operational needs of the organization. The roles, responsibilities and interfaces of everyone involved in safety and the safety management system are clearly defined. Adequate certification, monitoring and auditing are undertaken to provide assurance that the process is functioning as defined. Process improvement is achieved through a performance measurement system that monitors and assesses performance against set objectives. Improvement is also achieved through formal and in-formal feedback mechanisms that not only allow the effective reporting of deficiencies but also encourage suggestions for improvement. To be effective the "Safety Culture" must originate from the top with senior management providing an open and non-attributive environment.[17]

The Safety Case is the cornerstone of the risk-based approach. It specifies the through-life safety management plan for a specific installation. There is no single recognized definition of "Safety Case"; however, the following provides a good understanding of the term:

> It is universally true that the purpose of the safety case is for the operator to provide a clear, comprehensive, convincing, and defensible argument, supported by calculation and procedure, that an installation is, and will be, acceptably safe throughout its life. The safety case brings together an analysis of the risks facing an installation and the ways in which the operator plans to manage those risks. It therefore provides a vehicle for considering safety in a total or a 'holistic sense.'[18]

The Safety Case is based on a formal safety assessment that systematically assesses an installation through life from concept to disposal. The safety case is a living plan. It is updated when modifications are made to the installation and periodically to reflect changes in technology.[19]

To provide an appreciation for the rigour of the Safety Case, the main steps in a formal safety assessment are outlined in the following:

- Hazard Analysis — "the identification and quantification of the nature, likelihood and scale of potential accidents that may involve the equipment, its operators and where applicable, members of the general public and the environment";[20]

- Risk Assessment — "subsequently carried out to evaluate the combination of hazard severity, with its probability of occurrence together with the tolerability of sustaining the consequences. The conclusions drawn from the assessment should be recorded and will need to be justified. All sources of evidence must be referenced and the principle criteria and assumptions recorded";[20] and

- Hazard Control — "including statements of the measures to remove, mitigate, or control the consequences of these hazards through a combination of engineering and management measures. Particular attention is paid to the key hazards and features of emergency systems…. The process is to include reasoned judgements for the suitability of the particular control measure chosen."[20]

The "goal setting" approach, incorporating the Safety Case and Safety Culture concepts, is well developed and proven. The approach is used extensively in moderate- and high-risk industries such as the nuclear and offshore industries. Organizations that employ the approach have experienced not only improved safety but also improved per-formance.[21]

APPLICABILITY OF THE "GOAL SETTING" APPROACH TO SHIP SAFETY

The UK Health and Safety Executive initiatives, and subsequent changes to health and occupational safety legislation, had a significant impact on ship safety arrangements in the UK Ministry of Defence and the Royal Navy. Up until that time, the Royal Navy was exempt from ship safety legislation on the grounds of national security. This situation was changed and Crown bodies are no longer immune from obligations placed on the rest of the community. The Ministry of Defence, although allowed to self-regulate its ship safety, must employ best current practice and be no less effective than the civil system.[22]

The legislation caused the UK Ministry of Defence to closely review its "traditional" ship safety practices. Although the Royal Navy maintained a "good" safety record, oversights and potentially serious prob-lems were occurring. For example, the UP-HOLDER Class weapon handling system, as designed and built, had the potential to inadvertently flood the submarine. This incident and others indicated lapses during all ship life cycle phases and highlighted weaknesses in the traditional arrangements for safety in the UK Ministry of Defence.[23]

To address these weaknesses, the UK Ministry of Defence introduced the Ship Safety Management System in 1996. The UK Ship Safety Management System employs a "goal setting" approach that embodies the Safety Culture and Safety Case concepts. The Safety Culture is promoted through a well-defined framework of specifications, procedures and organizational structure. The organizational structure of the system, illustrated in Figure 1, emphasizes the importance that senior management places on the safety

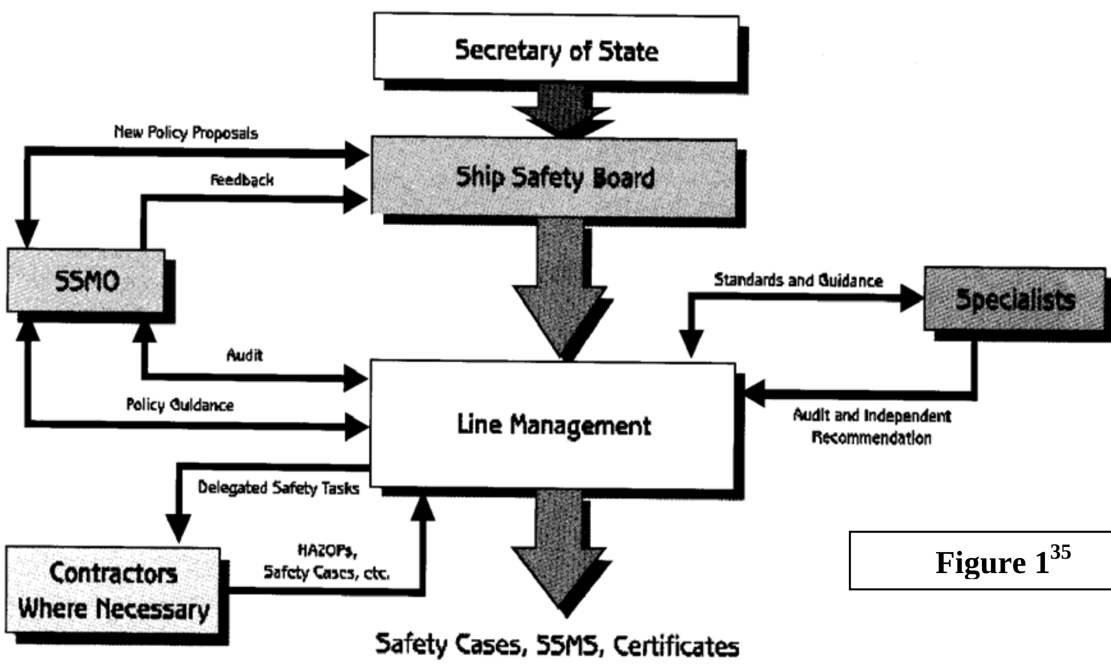

Figure 1[35]

culture. Continuous improvement is achieved, in part, by the process illustrated in Figure 2. The system mandates that a safety case be developed for each class of ship, starting from design concept, and maintained through to disposal. The UK Ship Safety Management System clearly demonstrates the applicability of a modern "goal setting" approach to ship safety.[24]

A key strength of the UK Ship Safety Management System is its ability to effectively respond to economic and operational pressures. To provide this flexibility, the system is structured to account for the increasing use of contracted services. When the system was established, consideration was given to what capabilities and capacities must be maintained in house. It was determined that expertise in certain unique military areas, such as vulnerability and survivability, needed to be maintained. In the remaining areas, the system provided the flexibility to use capabilities and expertise from whatever source made best sense for the situation. In situations where contractors are used, the contractor forms part of the safety management system. The contractor's roles, responsibilities and interfaces with the system are clearly defined. The contractor provides the necessary assurances consistent with the applicable safety case and is open to audit by the Ministry of Defence. The process and relationships are illustrated in Figure 1. It must be emphasized that at no time does regulatory responsibility pass outside of the ministry. In all circumstances the ministry must maintain sufficient in-house expertise to act as an intelligent customer and to ensure that regulatory requirements are met.[25]

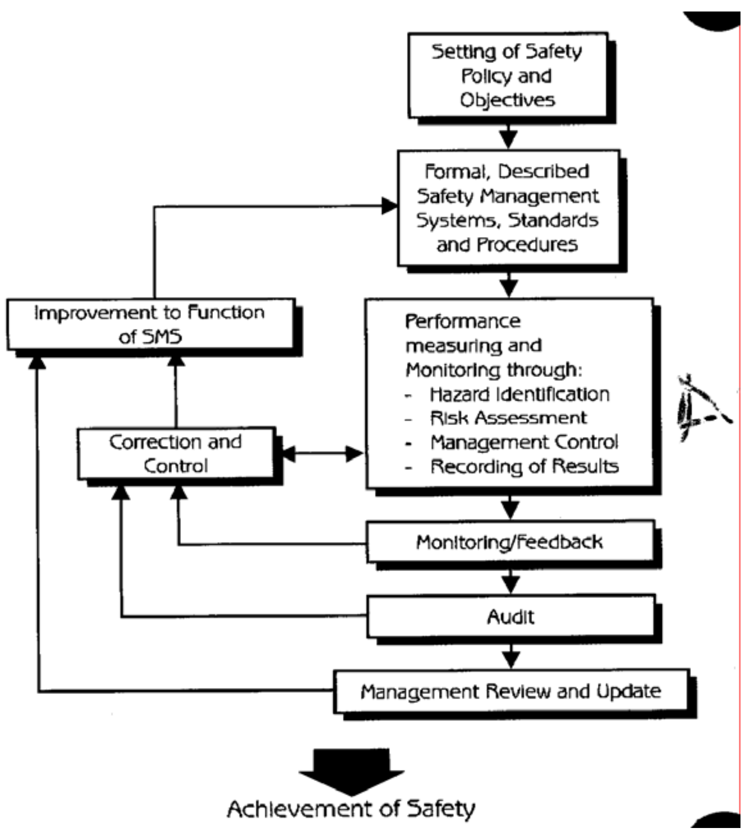

Figure 2[36]

The Royal Australian Navy (RAN) is another example of a navy that recognized the need to replace its "traditional" safety arrangements with a formal ship safety management system. Unfortunately, a major incident was needed to provide the necessary impetus to change. On 05 May 1998, four naval personnel died in a fire that occurred in the engine room of HMAS WESTRALIA. The Board of Inquiry found that the factors contributing to the incident were symptomatic of wider safety management problems in the RAN and the contractor organization responsible for the last maintenance period. Under growing fiscal pressure, the RAN had increased its reliance on contractors for engineering and maintenance but had not adequately defined the safety management requirements and relationship between both parties. Subsequent to the HMAS WESTRALIA Board of Inquiry, the RAN established the NAVSAFE program, which is similar to the UK MoD Ship Safety Management System.[26]

The broad applicability and acceptance of formal ship safety management systems is further demonstrated by the commercial shipping industry. To address the problem of significant ship losses, the International Marine Organization (IMO) developed the International Safety Management System (ISM). The ISM, although not as rigorous as the RN Ship Safety Management System and RAN NAVSAFE program, is based on the same underlying principles. The first phase of the International Safety Management (ISM) system went into effect 01 July 1998. The final phase will go into effect 01 July 2002.[27]

CURRENT CANADIAN NAVAL SAFETY REGIME

In general, the arrangements for safe-ty in the Canadian Navy are based on the "traditional" approach to safety. They are similar to the arrangements maintained by the RN and RAN prior to their establishment of formal ship safety management systems. There are, in fact, numerous historical ties between Canadian and Royal Navy safety ar-rangements. Unfortunately, like other tradi-tional safety arrangements, Canadian naval safety arrangements have a number of funda-mental deficiencies. The following section gives an overview of current safety arrange-ments and then provides illustrative examples of the deficiencies in those arrangements.

The Canadian Navy does not have a comprehensive approach to safety. The policy framework for the Navy is limited to the CF General Safety Program that is based on Treasury Board Occupational Safety and Health directives. The primary focus of the program is industrial applications and safety hazards in the workplace. The program is organizationally based, which essentially limits the resolution of problems to within the immediate purview of an organization and its Commanding Officer. Through-life (ie, design, building, testing, certification, training, operations and maintenance) system safety is addressed in an ad hoc manner through a large number of independent standards, speci-fications and other prescriptive requirements. The responsibilities of, and relationships be-tween, the various commands, operational authorities and technical authorities are not well defined. There is no integrated formal feedback mechanism to effectively commu-nicate lessons learned and to enhance overall safety. Overall, there is considerable potential for oversights.

The first illustrative example of problems with naval safety arrangements is an incident involving a fatality that occurred on HMCS REGINA on 15 October 1995. During a Replenishment At Sea (RAS) evolution, a wire strop holding a snatch block parted and the snatch block struck a sailor in the head. The cause of the accident was an unauthorized, untested jury rig. Looking beyond the specific cause of the accident, the Board of Inquiry found that there was a series of deficiencies that contributed to the incident. These deficiencies included problems with operational procedures, training, equipment deficiency correction procedures and documentation. The cumulative effect of these deficiencies demonstrated "systematic shortcomings within the navy as a whole".[28] Despite the broader implications the incident had on overall ship safety, the recommendations of the Board of Inquiry were limited to seamanship and Replenishment At Sea arrangements.[29]

The next example is a Continuous Improvement Project on the Certification of Shipboard Lifting Appliances, conducted by Fleet Maintenance Facility Cape Scott in 1997. This example provides further insight into the shortfalls in lifting appliance certification and overall safety management. The project team found that the current approach to certification, which is based on a prescrip-tive standard, was not appropriate for life cycle certification. Key deficiencies includ-ed a lack of guidance on design and acquisition, poor document control and traceability, and insufficient links between the equipment life cycle phases. Overall, the project team found that safety management was inade-quate. In addition to safety-related issues, the project team found that the current prescriptive approach was unnecessarily costly and had an unwarranted impact on operational schedules. A stakeholder group, including the Design Authority, operators and maintainers, supports the report and is currently taking steps to establish a better through-life certification process.[30]

During the last decade of OBERON class submarine operations there were a number of incidents that highlighted the need for a comprehensive safety program. In the late 1980s, a "hull valve crisis" occurred due to inadequate quality assurance of valves exposed to full diving depth. In response to the "crisis", the Naval Engineering Unit (Atlantic) developed an interim specification to address the specific issue of hull valve quality assurance. The interim specification remained in effect until the class was decommissioned.[31] During the refit of HMCS OJIBWA in 1995, an escape tower, being built to USN specifications and subject to USN inspection, failed to meet quality requirements and was scrapped. A Continuous Im-provement Project, which was established as a result of the incident, found significant de-ficiencies in the quality management of sub-marine welding. The welding standards and specifications in place had not been revised in decades and did not reflect current materi-als, processes and quality requirements. As a result of the incident, considerable effort was put into establishing a quality management system for welded steel structures.[32] In 1996, Fleet Maintenance Facility Cape Scott obtained an ISO 9000 registration. The first major undertaking for the facility as an ISO 9000 organization was the ONONDAGA refit. In preparation for the refit the facility found that there were no quality management requirements specified to support Safe to Dive certification. The only assurances required by the Design Authority that the sub-marine was materially safe to dive was the signature of the three Engineering Division Heads in the facility. In support of its ISO 9000 certification, and not at the request of the Design Authority, the facility developed a comprehensive quality management system to assure that all systems and material affect-ing Safe to Dive certification met current requirements.[33] There are a number of recurring themes in these examples. In each case prescriptive specifications had become obso-lete. Lessons learned from each incident, de-spite their applicability, were not applied to other aspects of submarine safety. The root problem in all these examples was inadequate safety/quality management.

The final example occurred during the undocking of CFAV FIREBIRD on 27 November 1996. During the evolution, the vessel made an uncontrolled descent down the marine railway in Halifax. The specific cause of the incident was a worn hauling chain that came unseated from the hauling sprocket. The Technical Investigation found that the root cause of the incident was poor inspection and maintenance. There were no formal planned maintenance and inspection routines for the facility, and there was no documenta-tion supporting the Safe to Operate Certificate. The report recommended the establish-ment of a formal inspection and maintenance program that includes third-party certification.[34]

The number and severity of safety incidents in the Canadian Navy are likely to increase due to continuing fiscal pressures. The navy has enjoyed a good safety record with the current safety arrangements because of competent and dedicated personnel. In the mid-1990s budget cuts led to significant "downsizing" in the Naval Engineering and Maintenance community. The Director General Maritime Engineering Program Management (DGMEPM) division was cut by 50% and the Naval Engineering Units were reduced by 30%. In some cases complete capabilities were eliminated. The Navy no longer has the inherent experience, knowledge and resources to address the oversights of the existing safety arrangements. In response to this situation the Navy has increased its reliance on contracted expertise and support. Unfortunately, due consideration has not been given to the implications of using contractors.

The discussion above highlights numerous problems with Canadian naval safety arrangements. These problems include deficiencies in the acquisition process, operational procedures, training, equipment deficiency correction procedures, operation and maintenance documentation, document control measures, communications, and life cy-cle management. The recurring nature of these problems indicates a systemic problem. In summary, Canadian naval safety arrangements suffer from the same fundamental problems inherent in all traditional safety arrangements. There is no coherent, overarching policy framework for safety management that covers safety through life and across the organization. The prescriptive requirements are not adequately maintained and are no longer appropriate in the current fiscal and operational environments. The deficiencies presented in this section, and the lessons learned by the UK Health and Safety Executive inquiries and other navies, indicate that there is a significant safety risk associated with continuing with the traditionally-based naval safety arrangements. This makes a compelling argument in support of the need for change.

THE WAY AHEAD

The systemic problems in the Navy's safety arrangements warrant fundamental change. To effectively address shortfalls in the safety arrangements, it is proposed that the Navy establish a formal ship safety management system centred on a "goal-setting" approach that incorporates the Safety Culture and Safety Case concepts. This approach re-quires the establishment of an organiza-tion-al-level framework that will enable the effective "management" of safety and continuous improvement of safety practice. The approach provides a rational and rigorous meth-od to evaluate the safety needs of ships, facil-ities and equipment through life. Ultimately, it provides significantly greater assurances of safety than the current arrangements and clearly demonstrates due diligence. In addition to enhanced safety, this approach provides a number of other potential benefits such as cost savings, increased flexibility and effective response to change. Commercial industry has proven the effectiveness of the "goal-setting" approach and other navies have clearly demonstrated the direct applicability of this approach to ship safety management.

This paper will not recommend a specific ship safety management system for the Canadian Navy. A study needs to be undertaken to determine the most effective system for the specific needs and objectives of the Canadian Navy. The ship safety management systems established by the Royal Navy and Royal Australian Navy are good examples. It is recommended that extensive use be made of the experience and work of these two navies.

It is considered that the cost of a formal safety management system would not be significant. A rough order-of-magnitude estimate is that it would take a small project team of 15 people, a budget of several hundred thousand dollars, and approximately two years to develop and establish a system. The system would make extensive use of the ex-isting establishment. The only increase in es-tablishment would be a safety management system organization responsible for develop-ing and maintaining policy, auditing and monitoring the system, and providing guid-ance on use of the system. The long-term op-erating costs are likely to be low. It could be argued that the cost savings associated with improved efficiency would offset the costs.

CONCLUSION

Canadian naval safety arrangements are based on a traditional prescriptive approach. Public inquiries into a number of disasters in the United Kingdom found that there are fundamental deficiencies with such an approach. The lack of a coherent management framework and inadequate attention paid to operational issues were major contributing factors to the disasters. The inquiries also found that prescriptive regulation is inappropriate for modern times. The assessed inadequacy of traditional safety arrangements, as they apply to ship safety, is supported by the experiences of the Royal Navy and Royal Australian Navy. Both navies recognized shortcomings in their safety arrangements, which were similar to Canadian naval arrangements, and established formal ship safety management systems.

A brief review of recent incidents in the Canadian Navy gives cause for concern over Canadian naval safety arrangements. The review highlighted deficiencies in the acquisition process, operational procedures, training, equipment deficiency correction procedures, operation and maintenance documentation, document control measures, communications and life cycle management. The deficiencies were of a recurring nature, indicative of a systemic problem. The Navy's good safety record and the apparent success of the current safety arrangements can be attributed to the experience and competence of the individuals involved. Unfortunately due to budget cuts, naval engineering and maintenance personnel have been sig-nif-icantly reduced and they can no longer be counted on to address the shortfalls in the safety arrangements. In conclusion it is considered that naval safety arrangements can no longer provide adequate assurances of safety.

To address the deficiencies in naval safety arrangements, it is recommended that the Navy establish a formal ship safety management system. The system should be based on a "goal setting" approach that incorporates the Safety Case and Safety Culture concepts. The approach is proven and widely accepted in commercial industry and several comparable navies.

It is recommended that a study be undertaken to develop a system that best meets the needs and requirements of the Canadian Navy. It is considered that the cost of a formal safety management system would not be significant. A rough order-of-magnitude estimate is that it would take a small project team of 15 people, a budget of several hundred thousand dollars, and approximately two years to develop and establish a system.

NOTES

[1]Bob Irving, *Welding's vital part in major American historical events* (American Welding Society, <http://www.amweld.org/about/blockbuster.html>), 09 April 2001.

[2]J. Wang and S.M. Zhang, "Management of Human Error in Shipping Operations" (extract from *Professional Safety* (Park Ridge, Vol 45, Issue 10 (Oct 00)), p 2.

[3]Cdr Kathy Ozimek, USN, "Risk Management Reduces Human Error" (extract from *US Naval Institute Proceedings*, Vol 123/1/1, 127, January 1997), p 75.

[4]In 1987, the ferry Herald of Free Enterprise capsized while leaving Zeebrugge harbour. The bow doors had been left open, which allowed the ingress of water. 193 people died in the incident.

[5]In July 1988, an explosion occurred on the Piper Alpha oil rig in the North Sea. The explosion caused a fire that destroyed the entire platform. 167 people died in the incident.

[6]In November 1987, a fire erupted in the Kings Cross underground station in London. 31 people died in the incident.

[7]In September 1988, a wiring error led to a series of faults that caused a head-on collision between a commuter train and a parked train at the Clapham Junction railway station in London. 35 people died and 69 people were seriously injured.

[8]J.T. Stansfeld, *The Safety Case* (Lloyd's Register Technical Association, Paper No 3, Session 1994–95), pp 4–7.

[9]*Ibid*., p 9.

[10]*Ibid*., pp 4–7.

[11]*Ibid*., p 9.

[12]*Ibid*., pp 4–9.

[13]*Ibid*., p 4.

[14]*JSP 430 Ship Safety Management System Handbook*, Volume 1, Issue 1, January 1996 (UK Ministry of Defence publication) Sec. 4, p 10.

[15]Stansfeld, p 7.

[16]*JSP 430…*, Sec. 1, p 3.

[17]*Ibid*., Sec. 1, pp 3–4.

[18]Stansfeld, p 10.

[19]Stansfeld, p 13.

[20]*JSP 430…*, Sec. 4, p 7.

[21]*MoD Ship Safety Management — Ship Safety Management* and *JSP 430*, Ship Safety Management Office, 1997 (UK Ministry of Defence publication) p 3. *Australian Book of Reference (ABR) 6303, RAN Safety Management System* (Defence Publishing Services, Department of Defence, CANBERRA ACT 2600) p 1–2.

[22]*JSP 430…*, Sec. 1, p 3.

[23]*JSP 430…*, Sec. 1, p 1.

[24]MoD Ship Safety…, pp 3–7.

[25]*JSP 430…*, Sec. 1, p 1; Sec. 4, p 1; Sect 5, p 1.

[26]*Report of the Board of Inquiry into the fire in HMAS WESTRALIA on 5 May 1998* (Defence Publishing Services, Department of Defence, CANBERRA ACT 2600) DPUBS: 32871/98, pp 11–13, Australian Book of Reference (ABR) 5454, RAN Technical Regulatory System (Defence Publishing Services, Department of Defence, CANBERRA ACT 2600), pp 1–3.

[27]Alex Maurice, "Marine Insurance Industry Undergoes Sea Change", extract from *National Underwriter*, Chicago, Vol 103, Issue 27 (Jul 99), pp 22–24.

[28]MARL: 1080-0097/2 (96) (N00 Comd), 21 November 1996.

[29]Interview with LCdr John Newton, 29 January 2001.

[30]*Fleet Maintenance Facility Cape Scott Continuous Improvement Project 97–283, Certification of Shipboard Lifting Appliances*, Interim Report, 13 February 1998.

[31]32549-114 (DMPPD 3-5/10-6), 15 March 2000.

[32]*Fleet Maintenance Facility…Project 95-04, Quality Management of Welded Structures*, Final Report, 12 July 1996.

[33]*Fleet Maintenance Facility…Project 96-01, Sub-marine Safe to Dive Certification*, Final Report, 12 July 1996.

[34]FMFCS: 1080-1 (HF31-5), 06 February 1997.

[35]*MoD Ship Safety Management — Ship Safety Management* and *JSP 430*, Ship Safety Management Office, 1997 (UK Ministry of Defence publication) p 5.

[36]*Ibid*., p 6.