SAFETY MANAGEMENT IN SUBMARINES

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Abstract

Safety has long been a byword for everyone involved in submarine activities. Different aspects of submarine safety, not surprisingly, require a different focus. What is needed, however, is the 'glue' to bind different but related safety programs together to ensure that prevention, education and mishap investigation have a common focus. Only then can navies be sure they are taking all reasonable steps to provide a safe occupational environment and to prevent submarine safety becoming "an engineer's plaything". The challenge is not to create too daunting an organisation which could lead to a culture of avoidance among those towards whom the program is most targetted. The Royal Australian Navy has developed such a structure with its SUBSAFE Program which is rapidly becoming recognised as the premier submarine safety organisation of its type. This paper will describe the background to the formation of the SUBSAFE Program and its implementation against the backdrop of the introduction of a new class of submarines.

Introduction

It is variously estimated that 70-80% of mishaps occur as the result of some form of human error. Thus, while it is unthinkable not to devote significant attention to preventing a mishap being caused by material failure, the problem is that senior management often find it difficult to invest in a safety program where the only tangible outcome is the continued existence of an asset. In this paper, I will describe how the RAN Submarine Safety Program evolved from a risk management process associated with the New Submarine Project to a safety management system for all aspects of submarine safety.

Background

Safety was brought into focus in the most tragic way following the loss of USS THRESHER in 1963 when material failure was identified as the prime culprit. More recent mishaps such as the fire suffered by the Dutch submarine WALRUS in build, the cracking suffered in steel used in the US submarine SEAWOLF, the fire suffered underway by USS BONEFISH, the sinking alongside of USS GUITARRO and the collision, sinking and subsequent escape from the Peruvian submarine PACACHO have all played their part as defining moments in the history of the RAN SUBSAFE Program. In a non-military situation, the fire in the North Sea oil production platform Piper Alpha has also had its relevance. All played some part in defining a requirement to ensure that the lessons, which resulted from the analyses, could be

applied to a new class of submarines being built by a country without any experience in building that type of vessel.

Structure

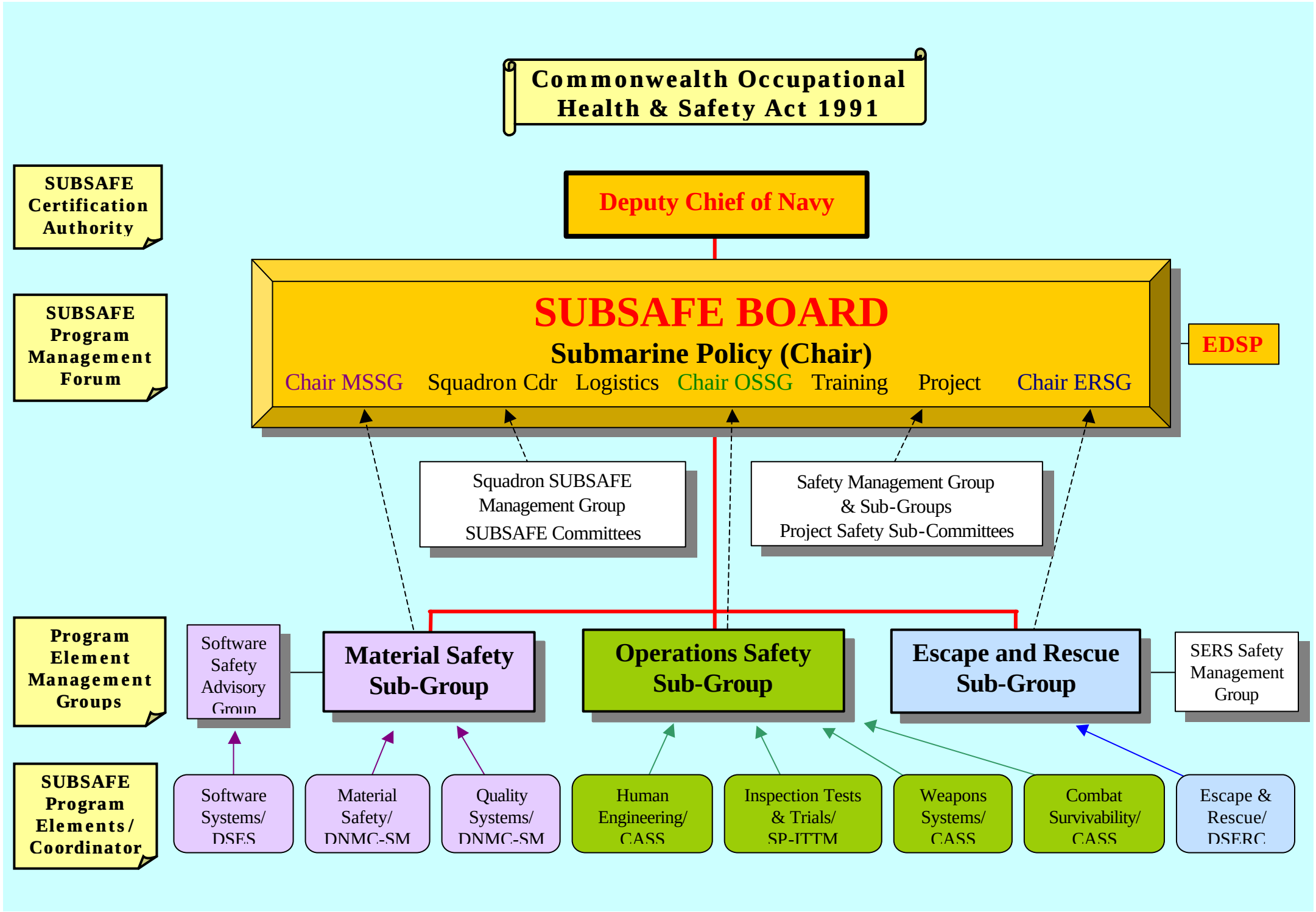
In defining the requirements of a safety program, the first task was to define the areas in which the greatest efforts needed to be focussed. Accordingly, the ten elements that, until recently, made up the RAN Submarine Safety Program were:

Elements		**Significant Mishap/Driver**
Material Safety		THRESHER sinking
Quality Systems		THRESHER, SEAWOLF cracks
Software Systems		Fly-by-wire ship control system
Escape and Rescue		PACACHO escape
Human Engineering		GUITARRO sinking, Piper Alpha fire
Shock	}	Trials Requirement
Torpedo Impact	} Combat Survivability	Exercise safety
Survivability Analysis	}	WALRUS fire
Inspection, Tests and Trials Safety		New build requirement
Weapons System Safety		UPHOLDER tube problems

Each of the elements has an authority identified responsible for developing and maintaining the safety plans and documentation and each is associated with a review panel or group of subject matter experts known as a Sub-Group. Two Sub-Groups were initially formed, the Material Safety Sub-Group and the Escape and Rescue Sub-Group. A third, informal group known as the Sea Training and Trials Group was alluded to in all documentation but was not brought "into the fold" in a more formal sense until recently. I will discuss more on that issue later.

The Sub-Groups answer to the SUBSAFE Board which comprises all the functional areas with a submarine responsibility as well as those who bring the reports of a subordinate group to the table as can be seen in Figure 1. While the Board has no executive power as such, it is formed with the authority of the Deputy Chief of Navy who has corporate responsibility for safety within the Navy. The Board is supported in the day-to-day running of the program by a full-time Executive Director.

A recent variation has resulted in the merging of Shock, Torpedo Impact and Survivability Analysis into a single element – Combat Survivability – which is managed by the newly-formed Operations Safety Sub-Group.


Commonwealth Occupational Health & Safety Act 1991
SUBSAFE Certification Authority
Deputy Chief of Navy
SUBSAFE Program Management Forum
SUBSAFE BOARD
Submarine Policy (Chair)
Chair MSSG
Squadron Cdr
Logistics
Chair OSSG
Training
Project
Chair ERSG
EDSP
Squadron SUBSAFE Management Group
SUBSAFE Committees
Safety Management Group & Sub-Groups
Project Safety Sub-Committees
Program Element Management Groups
Software Safety Advisory Group
Material Safety Sub-Group
Operations Safety Sub-Group
Escape and Rescue Sub-Group
SERS Safety Management Group
SUBSAFE Program Elements / Coordinator
Software Systems/ DSES
Material Safety/ DNMC-SM
Quality Systems/ DNMC-SM
Human Engineering/ CASS
Inspection Tests & Trials/ SP-ITTM
Weapons Systems/ CASS
Combat Survivability/ CASS
Escape & Rescue/ DSERC

Hazard Log

With a platform with as many complexities as a submarine, it is vital that hazards, perceived or real, are properly documented and tracked. It is also important to apply effort to rectifying them in proportion to the risk. The Hazard Log is therefore an essential tool in the process of identifying, reviewing and removing a hazard. The log itself is a database containing a description of the hazard, the undesired outcome presented by the hazard, the hazard risk index, the officer responsible for the latest action and the review forum. The Hazard Risk Index is generated from a matrix table which considers severity and probability as shown in Figure 2. All correspondence, opinions, comments and other documentation relevant to the subject are captured electronically so that, even when the hazard is closed, the information remains and can be viewed should the next generation decide to re-invent a wheel. The value of a Hazard Log cannot be understated and needs to be an integral component of any safety system.

	Hazard Severity			
Hazard Probability	**Catastrophic**	**Critical**	**Major**	**Minor**
Frequent $x > 10^{-1}$	1	3	7	13
Probable $10^{-1} > x > 10^{-2}$	2	5	9	16
Occasional $10^{-2} > x > 10^{-3}$	4	6	11	18
Remote $10^{-3} > x > 10^{-6}$	8	10	14	19
Improbable $10^{-6} > x$	12	15	17	20

1 – 5	**Unacceptable**
6 – 9	**Undesirable**
10 – 17	**Acceptable with Review**
18 – 20	**Acceptable without Review**

Figure 2: Hazard Risk Index Matrix

Review Forum

You'll have noticed the terms "Acceptable with Review" and "Acceptable without Review". The fora for reviewing a hazard and determining its acceptability or otherwise are the Sub-Groups which subsequently report the outcomes of their review to the SUBSAFE Board.

The Sub-Groups comprise all the experts on the particular subject and, through agreement to accept various actions, are able to monitor as many safety related activities as possible.

Leadership

The single biggest challenge facing a safety program, especially one which builds on previous experience, is to overcome the catchcry of "We've always done it this way!" There is an enormous amount of truth in this but, with reduced levels of experience, different technology and a far more demanding legislative environment, the processes surrounding safety have to be far tighter than would previously have been the case. As long as the navies of the world continue to be led by warriors, any change to a navy's culture such as the inculcation of safety has to be introduced through the leadership of those warriors. Thus, the chairmanship of the SUBSAFE Board is vested in a submarine command-qualified officer on the staff of the Deputy Chief of Navy and the position of Executive Director is designed to be filled by a Seaman Officer (a warrior). This is not intended to belittle the role of the engineers, but rather to support them and enhance their outputs. Submarine mishaps, and I use the term "mishap" instead of "accident" because of the human aspect of most undesired events, are almost invariably caused by some form of human error. The involvement of operators is therefore necessary if the safest possible work environment is to be developed through development of a "safety culture".

Operational Risk Management

Today's Quality Management systems and other processes which have developed to reduce manufacturing and maintenance costs have, therefore, done much to reduce the risk of material failure. What those systems have not addressed is how to reduce the risks of human error to an acceptable level. At the same time, mere avoidance of risk can be even more dangerous especially if such practice is tagged as a safety issue as the good name of safety runs the risk of being besmirched. A recent development in this area has come from the United States. Known as Operational Risk Management, it operates on the same basic principles as Hazard Risk Analysis but concentrates not only on the risks associated with a particular event but its effect on Mission Effectiveness. The aim is not to constrain operators but, with greater visibility of cause and effect, to allow them to explore corners of the envelope that would otherwise not have been encountered until a time of conflict.

Results from the USA have been particularly impressive: the US Army Aviation Corps improved its safety record out of the four services from worst to best in three short years and the US Navy credits ORM with reducing its operational Class A mishaps (which include damage greater than $1m and death) from 83 to 20, saving $US900m in that area alone and its deaths (operational and recreational) from 232 to 56.

Implementation of ORM has been allocated to the Operations Safety Sub-Group with a view to demonstrating to the remainder of the Australian Defence Forces (ADF) the value of such a system.

U.S. Navy	FY96	FY97
Operational Class A Mishaps	80/**83**	80/**20**
Deaths		
Operational	57/**70**	58/**12**
Non-Operational		
Motor Vehicle	139/**128**	130/**38**
Shore/Recreational	49/**34**	41/**6**
Total	245/**232**	229/**56**

Table 1: USN Improvements attributed to Operational Risk Management

Operations Safety Sub-Group

The final link in the SUBSAFE chain was recently forged when the Operations Safety Sub-Group was formed. Bringing together the Sea Training Group, the Submarine Training and Systems Centre, Submarine Squadron and the Maritime Command, it will allow a more consistent approach to safety than has previously been the case. It will also provide better visibility of the safety process to the operational commander and allow for more effective review of hazards with an operational perspective. Most importantly, today's and yesterday's submarine commanding officers are involved. There is no better way to implement change than to involve the "changees".

Conclusion

Submarine safety management is a complicated but necessary part of owning submarines. To be effective, it needs to involve engineers, designers, logisticians, trainers and operators with meaningful commitment from top management. The RAN Submarine Safety Program is unique among the safety programs in the rest of the world because of its structure and the "glue" which joins all the various aspects together – the SUBSAFE Board.