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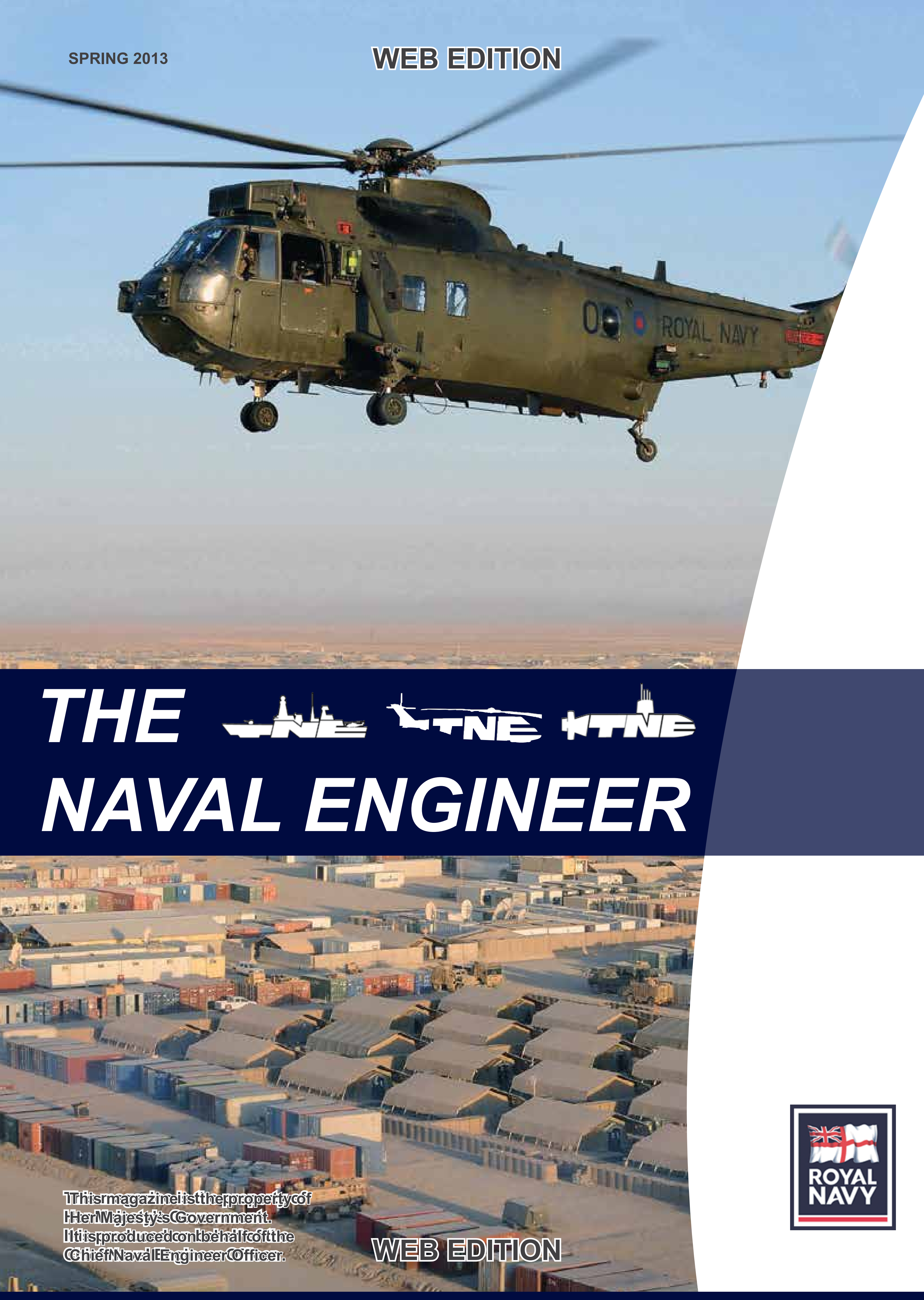


# THE NAVAL ENGINEER

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WEB EDITION

ROYAL NAVY

# THE NAVAL ENGINEER

## Contents



***• The magazine is published for information, entertainment and to promote discussion on matters of general interest to engineers of all sub specialisations (Air, Marine, Weapon and Training Management).***

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***Photographs:***
***The front cover: A Sea King HC Mk4 deployed on Operation Herrick – see article on Page 29 (Photo by POA(Phot) Mez Merrill, UK MOD/Crown copyright 2012).***
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# The Naval Engineer




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# Editor's Corner

"Where are we, and where are we going?" Questions which we ask ourselves on a regular basis – on a car journey, about personal relationships, considering financial matters and a whole lot more. Equally, as an organisation we should not only ask the same questions, but analyse and act upon the responses – that is, to ask "How do we get there from here?". That, after all, is just a part of good management – and should be part of normal business. Recently I was in an audience of General Service engineers for an NPT(E) Roadshow which attempted to answer these questions as they relate to manpower issues within the Engineering Branch.

The "Where are we?" part was (relatively) straightforward – we know how many RN engineers are on the books, what rank/rate they are, and what the current manning requirement is – and thus where the gaps and overbearings are. Without going into the details, it's clear that there are significant imbalances between what we require and what we have – as evidenced by the article by Lieutenant Commander O'Shaughnessy in the Winter 2012 edition of TNE.

As for "Where are we going?", that's clear too – a Navy of 30,000 (the SDSR figure – of which a third will be engineers), with challenging new equipment on the way (eg in Type 26, QEC), needing people to operate, maintain, diagnose and repair.

"How do we get there?" – not so easy to answer! Part of this is being studied in the manning trials referred to in the Winter 2012 article (which are ongoing, and the jury is still out); much tweaking and tuning will be required and how, when and if the results are applied remains to be seen. More significant is the need to sort out the structural imbalances – not enough people in some rates or ranks, and too many in others. The manning authorities have a number of "levers" to address this – adjusting promotion numbers, offering extensions of service, requiring notice-givers to serve out their full notice etc – and these are being used. Promotion prospects for those qualified and eligible are looking pretty good at present – so look for opportunities to show how good you or your people are – such as stepping up to fill a temporary gap – make sure JPA is accurate and your reports actually support suitability for promotion (if justified!).

The rest of "How do we get there?" – what will the Branch look like in the future – is also being worked on. Engage in the debate, through the chain of command, with CNEO's Warrant Officer (WO Dan Archer – FLEET-CNEO-WO1), or with your Career Manager!

**Thinking of writing for TNE? Deadline for articles or letters is Friday 26 April 2013.**
**This issue of The Naval Engineer is also available on the Intranet at *http://defenceintranet.diiweb.r.mil.uk/DefenceIntranet/Library/* (search for TNE)**
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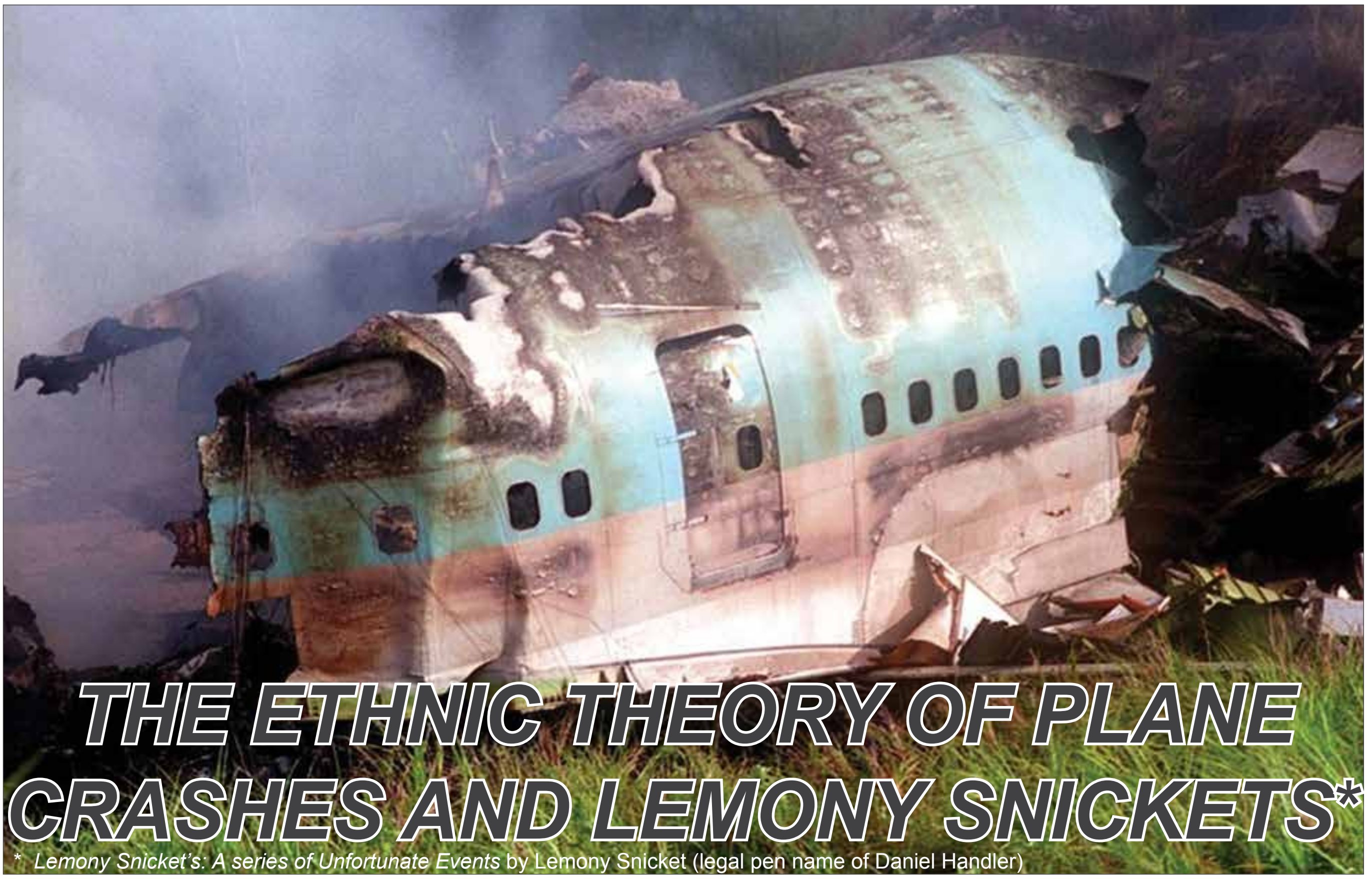

# THE ETHNIC THEORY OF PLANE CRASHES AND LEMONY SNICKETS*

* *Lemony Snicket's: A series of Unfortunate Events* by Lemony Snicket (legal pen name of Daniel Handler)

**NOTHING TO DO WITH ME?**
Perfectly serviceable aircraft in controlled flight flies straight into the ground – that's got nothing to do with me as an engineer!
**THINK AGAIN!**
Read on – there are lessons for all of us!



## *By Captain Guy Dabell MA, MSc, CEng, FIMarEST, FCMI RN, Future Submarines PT and Commander Paddy Parvin MSc MBA CEng CMgr FIMarEST RN, FLEET-CAP SM E NPOS SO1, Navy Command*



Guy Dabell joined the RN in 1981, studying at RNEC Manadon and RNC Greenwich before joining HMS Trenchant, in build at Barrow-in-Furness, in 1988. After sea time he returned to Barrow to take HMS Vanguard through the same process. This was followed in 1993 by three years as the management planner for NBC Clyde and promotion to Lieutenant Commander. He went back to sea in 1996 as the DMEO and then the MEO of HMS Victorious. In 2000 at the height of the 'dot com' boom, he joined the embryonic Defence Logistics Organisation (DLO) as a requirements manager in the DLO's E-Business Office, helping to set up e-commerce and Internet-based logistic systems. It was here that he was promoted Commander. He did the Joint Services Staff Course in 2002, gaining an MA in Defence Studies, and in 2003 he moved to MOD Main Building as a staff officer in the Resources and Plans Centre section. Returning to his engineering roots and back into the MESM fold, in 2006 he became the Head of the Design Authority Ships Systems and then the Submarine Programme Manager, both within the Submarine IPT; his work underpinned by an MSc in Engineering and Management. In 2009 he was appointed to NCHQ as FMEO(SM) responsible for in-service policy and standards for the operational submarines. After a year in London in 2011 as the Cap DUW Programmer Manager, he was promoted Captain and took up his present position as Chief Engineer (Marine Engineering) for the Successor Submarine Project.

Commander 'Paddy' Parvin is the Navy Command Nuclear Propulsion Operating Standards Officer, a role he took up in September 2011. Immediately prior to that he was Chief of Staff on the Successor Deterrent Programme and Submarine Technology Manager in the Future Business Group, Defence Equipment and Support. Having joined the RN in 1984, he gained a First Class Honours Degree from RNEC Manadon in 1988 before going into the Naval Nuclear Propulsion Programme. His engineering experience has been predominantly in Trafalgar class nuclear submarines between 1990 and 2002, but he considers himself privileged to have also served at sea in HMS Montrose, a Type 23 frigate, from 2005–2006, including completing a long Operation Telic deployment. He read a Masters Degree in Marine Engineering in-service, and additionally read for a Masters in Business Administration in his spare time, from which he became International MBA Student of the Year 2002. He is a Chartered Engineer and a Chartered Manager and is a FIMarEST.

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Korean Air Flight 801[1] was a Boeing 747 in perfect working order. It took off at 2250 on 5 August 1997 on a standard flight from Korea to Won Pat International Airport, Guam. The experienced Captain, in good health, had flown to Guam eight times previously. Just after 0120 the plane descended through the clouds and the flight crew could see the lights of Guam in the far distance. 20 minutes later, on a visual approach in rain, the First Officer couldn't see the runway and said "*Not in sight?*" Then the Ground Proximity Warning System called out electronically "*Five hundred feet.*" The Flight Engineer expressed his astonishment; "*How could this be?*" At 0142 the First Officer said "*Let's make a missed approach*", adding "*Not in sight.*" Three seconds later the Flight Engineer pleaded "*Go around.*" Too late, the Captain tried to pull up the plane out of its descent. It crashed into the side of a hill and 228 of the 254 onboard died. One of the survivors said "*You didn't have time to scream.*"

1. The Korean plane example in this article draws heavily upon Malcolm Gladwell's excellent book "*Outliers – The Story of Success*" and some transcripts from the investigation websites http://ns.gov.gu/guam/transcripts.html and http://www.ntsb.gov/publictn/2000/AAR0001.pdf. Pictures are both public domain.

What went wrong? Why was it so sudden? Three minutes before the crash, at 0139, the plane's conversations with the control tower were normal. What has it got to do with ethnicity? Why was Korean Airlines' safety record so poor? And what has this got to do with engineers? To answer these questions it is best to start to dissect the Lemony Snickets – the series of unfortunate events surrounding the crash.

There are latent technical issues, the landing is acknowledged as challenging, the crew is tired (human factor), the weather suddenly worsens (environmental issue) and the Korean Captain is mentally fixated on a visual approach. But other planes have survived similar scenarios, so why did Korean Air Flight 801 crash? The supposition of ethnic theory of plane crashes is that the Korean Captain crashed his plane because he was Korean. Consider the language used in the cockpit.

At 0124 the First Officer says "*Don't you think it rains more? In this area, here?*" Korean society has one of the most formal social hierarchies in the world. In the Korean language there are six different levels of conversational address depending on the relationship between parties. In addressing a superior officer, the First Officer is formally showing due deference. Dutch psychologist Geert Hofestede[1] has analyzed authority structures within different societies and has dimensionally measured the distinguishing facets. His 'Power Distance Index' (PDI) is a measure concerned with the attitudes towards hierarchy, specifically with how much a particular culture values and respects authority. In high PDI countries (of which Korea is one of the highest in the world), a speaker would be appropriately deferential to a superior at all times – even in a social setting. When the officers first met the flight Captain before they took off, they would have both bowed to him.

Low PDI countries have what linguists call 'transmitter orientated' speech – it is up to the speaker to communicate ideas clearly and without ambiguity. In Korea with its very high PDI structures, the communication is 'receiver orientated' – it is up to the receiver to decode and make sense of what is being said. In this case, the tired Captain wasn't in receive mode; he was unable to dissect the subtleties of what was being said to him.

There is communication that is transmitted and there is good communication that is received.

The linguists Fisher and Orasanu[2] have studied the issue above and in a scenario played out to numerous airline captains and first officers; there are at least six levels of possible communication to persuade a pilot to change course, each with a different level of mitigation:

1. **Command**: "*Turn thirty degrees right.*" Direct, explicit and with no mitigation. Air captains were most likely to choose this option.
2. **Crew Obligation Statement**: "*I think we need to deviate right about now.*" This request is softer, the 'we' indicates collective responsibility as immediate action.
3. **Crew Suggestion**: "*Let's go round the weather.*" Still collective with a 'we' but softer in approach.
4. **Query**: "*Which direction would you like to deviate?*" Softer still with the speaker conceding that he is not the decision maker.
5. **Preference**: "*I think it would be wise to turn.*" Saying that a decision may be necessary from the decision maker.
6. **Hint**: "*The weather ahead looks mean.*" The most mitigated response and the most deferential. First officers chose this most often but it is also the hardest to decode.

This is exactly the language used by the Korean First Officer at 0124 with his Level 6 hint: "*Don't you think it rains more? In this area, here?*" What he really wanted to say was perhaps a Level 3 crew suggestion; "*Captain, you have committed us to a visual approach with no backup plan and the weather is terrible. Your pre-descent brief was weak. Let us consider the alternatives.*" Similarly the Flight Engineer couched his concerns with a hint: "*Captain, the weather radar has helped us a lot.*" What he is really saying is that a purely visual approach is unduly risky and we should be using our instruments more.

As Flight 801 deviated to avoid the weather and descended too early the Captain was still

1. Hofstede, G. (20011) *Culture's Consequences: Comparing Values, Behaviours, Institutions, and Organisations Across Nations*. 2nd ed. Thousand Oaks, CA: Sage.

2. Fischer, U. & Orasanu, J. (1997) *Cultural Diversity and Crew Communication*. International Symposium on Aviation Psychology, 9th, Columbus, OH; 27 Apr.-1 May 1997 pp. 673-678.

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Crash site of Flight 801 and its proximity to the radio beacon (three miles from the runway)

confused. Despite the fact that he had mentioned the fact that the Glideslope[3] was inoperative in his pre-descent brief, he lost situational awareness. For example, at 0139:55, the Flight Engineer asked, "*Is the Glideslope working?*" Is this a Level 6 hint – I think you are wrong, what makes you think it is working? The Captain responded, "*Yes, yes, it's working.*" About 0139:58, an unidentified voice in the cockpit stated, "*Check the Glideslope if working?*" Another Level 6 hint – you are wrong. One second later, an unidentified voice in the cockpit stated, "*Why – is it working?*" Yet again, another hint but this time trying a different tack.

The clues and communication prompts were all there but not acted upon. At 0139, the approach tower controller had transmitted, "*Korean Air Eight Zero One ...cleared for the ILS Runway Six Left … Glideslope unusable.*" The First Officer responded, "*Korean Eight Zero One roger …cleared ILS Runway Six Left*", however, he did not acknowledge to the tower that the Glideslope was unusable. About 0140:00, the First Officer responded in the cockpit, "*Not usable.*" The crew are getting agitated – a Level 3 suggestion or statement of fact. Similarly, at 0140:22, an unidentified voice in the cockpit stated, "*Glideslope is incorrect.*"

3. ILS (instrumentation landing system) using radio and light arrays.

This time the Captain seems to have absorbed the hint/suggestion and responds, "*Since today's Glideslope condition is not good, we need to maintain one thousand four hundred forty [feet].*" However, about 0141:46, after the aircraft crossed the outer airport marker (1.6 miles to go), the Captain again stated, "*Isn't Glideslope working?*" He is still confused.

30 seconds later at 0142:19, the First Officer still cannot be fully assertive but says "*Let's make a missed approach.*" Despite the impending doom, his speech has only moved up from a hint to a Level 3 crew suggestion. Never did he consider a Level 1 command "*Captain, we are standing into danger, abort and make a missed approach NOW!*" They crashed six seconds later.

The official verdict of the incident was that with the Captain's preoccupation with the status of the Glideslope, failure to properly cross-check the aircraft's position and altitude with the information on the approach chart, and continuing expectation of a visual approach, the Captain lost awareness of Flight 801's position and crashed. Although the First Officer properly called for a missed approach six seconds before impact, he failed to challenge the errors made by the Captain earlier in the approach, when the Captain would have had more time to respond.

Significantly, the First Officer did not challenge the Captain – his ethnic and cultural background prevented him from being too critical of the Captain and limited effective communication. Since 1997, Korean Airlines has completely revamped its training, adopted English as the primary language (the common language of air traffic controllers) and concentrates on good communications. Its flight safety record is now one of the best in the world.

Could this happen in the Royal Navy? Does this tragedy have parallels with any RN events? Whilst we live in a relatively low PDI country we have a higher PDI dimension in the RN. Do we communicate appropriately? The fundamental theme throughout this article is that when multiple things go wrong, clear communication and teamwork can avert accidents. It is the last and arguably the most important difference (your last line of defence) between a successful operation in difficult circumstances and an accident.

## WHEN SHOULD THOSE ALARM BELLS IN YOUR HEAD RING?

When do you get alert, sit up straight, concentrate and start looking and listening to what is going on around you? When are you most at risk? When do you need to make sure those communications are crisp and succinct? Essentially when you are away from the norm:

- During tasks which span a handover.
- When safety systems (such as Minimum Safe Altitude Warning System) have been overridden.
- During deviations from normal workings (eg Flight 801 deviating to avoid weather in the descent). If deviations do occur, do a double check to ensure that all other assumptions are normal. Flight 801's crew had 'stepped down' their descent height too early as they were distracted by the

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weather and the lack of the Glideslope.

- Following a lengthy absence from work. The Captain of Flight 801 hadn't flown into Guam for a month.

- When handovers are between experienced and inexperienced staff. While the crew on Flight 801 were experienced, their cultural background, as exemplified by their high PDI score, prevented then from having a questioning attitude and an open discussion.

If this still seems entirely unambiguous and common sense, then why are the human error rates so high on Nuclear Propulsion Operating Standards Quarterly Report of safety? Complacency can creep up in any profession. Nobody can sit back and think they are safe. The following sections list many of the tools and techniques used to improve information flow. Whilst these lists below might seem to be lists of the blindingly obvious, it is amazing how often they are not given sufficient attention.

### HINTS FOR HANDOVERS

Communication can be written or verbal. An effective handover or pre-task brief sets the scene for subsequent actions. The HSE report "*Effective Shift Handovers – a Literature Review*" has some pertinent things to do. Compare the rest of Flight 801's performance with best practice:

- **Logs up to date. Establish a thorough baseline.** *Flight 801's chart was out of date.*

- **Have a procedure for handovers/briefs and follow it.** *Korean Airlines does have a standard procedure for descent briefs but the Captain didn't follow it.*

- **Have accurate carry forward of written information.**

- **Involve people working at the sharp end.** The most effective interventions are those where operators are involved as they know the risks and hazards and can contribute to the debate.

- **Give shift handovers and briefs an effective priority.** *The Captain's brief was too short.*

### IMPROVEMENTS – GOOD COMMUNICATIONS TOOLS AND TECHNIQUES

Below (Table 1) are some more tools and techniques to encourage good communications.

### WHEN IT COMES TO COMMUNICATION, ENGINEERS ARE THEIR OWN WORST ENEMY[4]

Studies have demonstrated or observed that the culture of engineering impedes the collaborative processes in team work and hinders good communications[5]. This seems to be a truism across a wide variety of engineering disciplines and from different cultural backgrounds[6]. Engineers come in many shapes and sizes (and WEs) and have been labelled amongst others as the creator (an artificer), geeks (Bill Gates), the maverick (a technology tinkerer) and the expert (any engineer)! Engineers are also seen as macho, with a competitive streak. Whilst this latter label may seem too strong, many studies have shown that engineers thrive in the mastery of their craft and the fact that they 'get it' and grasp new concepts faster than others. Engineers also thrive in putting others down and competitively demonstrating their mastery to others. If you think this view is too extreme, think about the RN push for professional recognition, encouragement for master's level studies, the questions on our professional boards, the way we grade ourselves and our technical back-bar talk.

Unfortunately technology bias has other consequences. In demonstrating the mastery of their art, engineers are likely to assert their professional opinions[7]. The more strongly that opinions are voiced, the less likely it is that subordinates and peers will to voice their own opinions, defying one of the basic ingredients of team successes – namely openness. On Flight 801, whilst the Captain wasn't an engineer, after he voiced his strong opinions no-one was likely to challenge him. Such an impact was seen during the Fukushima Event, when it is a matter of record that the Japanese Prime Minister was giving technical orders to those working on minimising the effects of core meltdown.

The second consequence of this fixation with the mastery of the engineering art is that team members are picked solely on their technical competence. For

4. Paul Leonardi, *The Mythos of Engineering Culture*.
5. Amongst others Ingram, S. & Parker, A. (2002) *The influence of gender on collaborative projects in an engineering classroom*. IEEE Transactions on Professional Communications, 45(1), 7-20.
6. Barley, S.R. (1996) *Technicians in the Workplace: Ethnographic Evidence for Bringing Work into Organizational Studies* Administrative Science Quarterly 41(3), 404-441.
7. La Fasto, F.& Larson, C. (2001) *When Teams Work Best: 6,000 Team Members and Leaders Tell What it Takes to Succeed.* Thousand Oaks, CA: Sage.

| | Speak Up | Encourage the Team | Communicate Openly |
|---|---|---|---|
| **Who?** | Everyone | Supervisors | Managers |
| **Tools and Techniques** | Time out for Safety | Safety conversations and training | Safety conversations and training |
| | Tool Box Talks | Tool Box Talks | Site visits |
| | Time for Health and Safety | Observation and feedback | Operators meetings |
| | Observations and feedback | Staff briefings | Staff meetings |
| | | | Peer reviews |

*Table 1: Tools and techniques*

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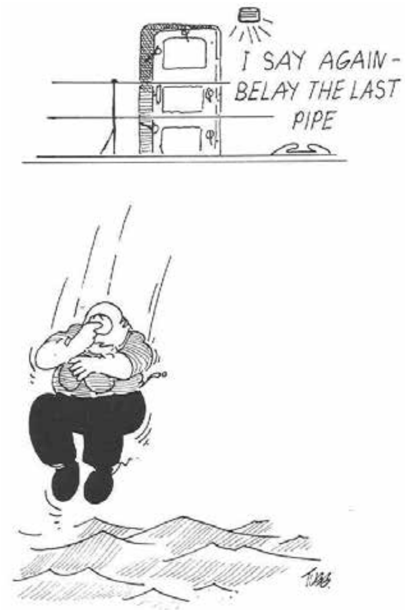
a team this may be sub-optimal in comparison to choices made considering a wider basket of human competencies. Finally, if engineers are seen as highly technical, competent and 'get it' from first principles, they are less likely to either seek support, read instructions, follow procedures (the maverick engineer), ask for directions or support other engineers who are wavering. In its worst guise, engineers can look down on someone who needs support and this works directly against the practice of bringing out the best in team members. Whilst not engineering, would other civvy organisations have a career course called the "Perisher"? The message here is that we cull the weak. The response is to master your craft which leaves less time for interaction skills.

In sum, engineers need to be aware of their 'blind spots' from their engineering cultural background and practise socialising more! To communicate, they need to be more human, with more empathy for their audience, speak with humility and de-tune the techiness of their message. If this is not done, the additional 'language barrier of engineers' gives the listener an additional level of meanings and interpretations to decipher. Keeping messages plain and simple has never been more apt.

**CONCLUSION – COMMUNICATION NEEDS TO BE APPROPRIATE**

Ships are places where hazard is latent (without proper management) and when we see something amiss and unsafe it is beholden on us all to speak out and ensure we are understood. Be willing to listen, when you have time, by adopting a soft communication style which can help identify issues and decode those 'soft' signals. Be objective – look at all the evidence and the signals before making a decision. Be just – safety communications are based on trust which requires fair treatment. If a subordinate shouts out with a Level 2 or Level 1 communication (order) and they are correct, then congratulate them on having the confidence to do the right thing. If they are wrong, their advice doesn't have to be taken. They need to be educated (gently) and the errors in their deductions assessed and corrected.




*... look at all the evidence and the signals before making a decision*

Remember:

**TIME OUT FOR THINKING / REFLECTION (1):**

***Effective Communication***[1] . . .

It is two way. It involves active listening.

It reflects the accountability of speaker and listener.

It utilizes feedback. It is free of stress.

It is clear. And if you are an engineer – talk nicely to non-engineers . . .

**TIME OUT FOR THINKING / REFLECTION (2):**

Some of you might be thinking that this is all well and good, but we are not Korean and we have a low Power Distance Index. Or do we?

Think of the parallels that have easily been drawn between the Flight 801 crash and a recent submarine grounding, for example:

When one or more people start to feel things are not right, they usually aren't.

It gets progressively worse when no-one seems to bother to listen to them.

1. Taken from the current NPOS Safety Culture Lecture.

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# COMPLIANCE OF RN SHIPS WITH NITROGEN OXIDE EMISSIONS LEGISLATION

**_Lieutenant David Blatcher MEng MSc IEng MIMechE RN_**
**_Electrical Development Officer, Electrical Systems Group_**

David Blatcher joined the RN as a University Cadetship Entrant in 2002, serving fleet time in HMS Invincible and HMS St Albans. He spent four years at the University of Southampton reading MEng Mechanical Engineering and working as an Assistant Training Officer with Southampton URNU and HMS Blazer. He completed SEMC at HMS Sultan and AMEO's time in HMS Cumberland. He was DMEO of HMS Westminster (briefly) then HMS Kent for an Op Telic deployment and upkeep in Rosyth. He recently spent a year at University College London, from where he graduated with an MSc with distinction in Marine (Electrical) Engineering, and now works as the Future Projects Officer in DES Ships' Electrical Systems Group.

**INTRODUCTION**

The Royal Navy's (RN's) diesel engines produce nitrogen oxides, sulphur oxides and particulate matter ($NO_x$, $SO_x$ and PM). These are a significant cause of human respiratory illnesses, degradation of the marine environment and acid rain [1]. Global and regional legislation is being introduced, principally by the International Maritime Organisation (IMO), to limit the quantities of these pollutants in exhaust gases [2].

It is ministerial policy to comply with environmental legislation so far as is reasonably practicable, and in support of the DE&S effort on this problem I looked at this subject for my MSc thesis. It was quickly apparent that complying with the $SO_x$ and PM limits is likely to be relatively straightforward through the use of low-sulphur fuels and particulate filters. $NO_x$ is, however, a more complex problem.

Highly restrictive $NO_x$ restrictions are due to apply to ships laid down after 1 January 2016, when operating in specified sea areas. At present there are plans to apply these restrictions around the coasts of the USA, Canada and Puerto Rico and it is likely that further areas will be specified in subsequent years. These 'Tier III' rules restrict $NO_x$ emissions to approximately 25% of the 'Tier II' level produced by contemporary diesel engines [3] [4]. In short, the RN needs to greatly reduce the $NO_x$ emissions produced by its ships in order to maintain global access [5].

Submarines will not be discussed at any length because, by making relatively small changes to their battery charging systems, their diesels may be designated as for emergency use only, exempting them from the legislation [3]. The use by surface ships of alternative fuels or non-diesel engines may permit compliance, although these approaches are associated with significant economic and safety penalties and were largely excluded from the scope of this study.

Several papers were published between 1994 and 2001 assessing how the RN and other navies could comply with Tier III emissions legislation, especially in the JNE [6] [7] [8] [9]. All of the techniques discussed had significant drawbacks or were at an early stage of development. Since 2001, published articles have focussed on the application of abatement technologies to civilian ships [10] [11] [12] [13] [14] [15]. Much of the material discussing developing technologies and existing systems has been produced by companies with a vested interest in their development and selection [16] [17] [18] [19] [20] [21] [22]. My thesis, summarised in this article, was an effort to address the need for an updated analysis of options for the RN.

At this stage it is important to point out the limitations of this study. Firstly, little information was found relating to the potential cost of abatement systems so the relative cost estimates used in this assessment are subject to a high level of uncertainty. Secondly, the assessments of the importance of design drivers in the 'Warship Constraints' section are based on personal judgement and experience of naval engineering as a Charge-Qualified Marine Engineer Officer. It is expected that the requirements weightings used in this analysis would be validated by a panel of subject matter experts before the recommendations are used to inform procurement decisions.

This article will briefly describe the constraints imposed by naval ships then discuss the suitability of various methods to reduce $NO_x$ emissions. Finally, I will explain how the weighted matrix method was applied to assess the suitability of different solutions for different ships and discuss the results of my analysis.

**WARSHIP CONSTRAINTS**

The Royal Navy, Royal Fleet Auxiliary and Royal Marines operate a wide range of diesel engines, ranging from the 18 MW medium-speed propulsion engines fitted to HMS Ocean to various high-speed units that are not subject to

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MARPOL Annex VI because they develop less than 130 kW. It is anticipated that a similar range of engines are likely to be used by RN ships for the foreseeable future. In RN ships (compared to non-naval ones), space and weight are usually limited, logistics are complicated, Defence standards apply and access for maintenance may be constrained [23].

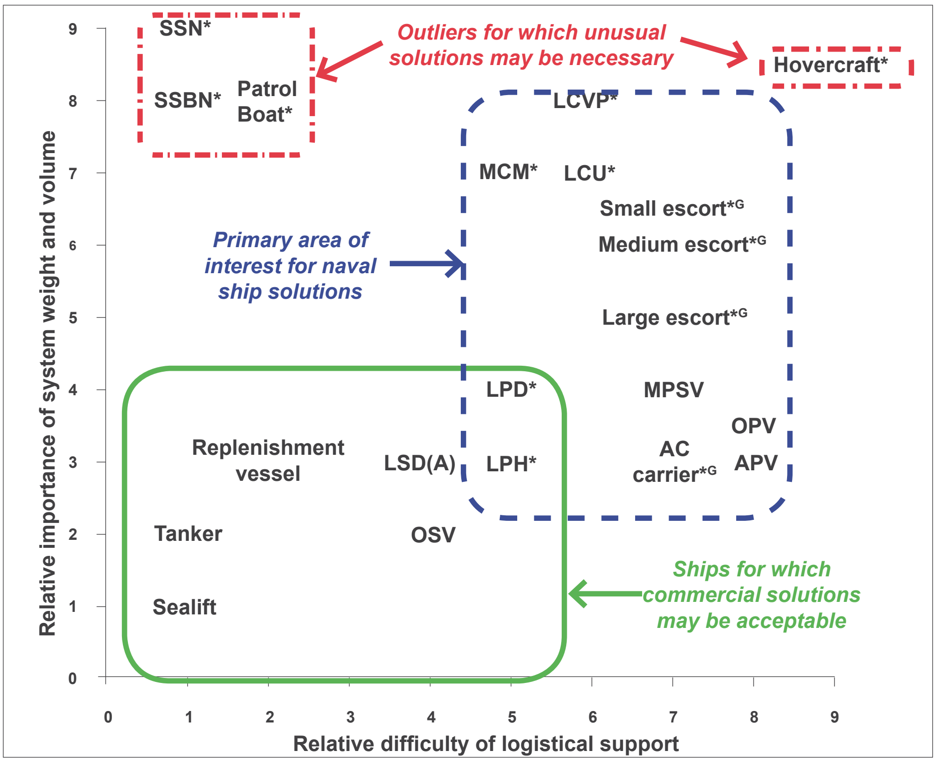
Design drivers that affect the selection of emissions abatement systems for the diesel engines in future RN ships, in order of decreasing perceived importance, are listed below. These and other naval-specific requirements must be addressed prior to the specification of a system for RN vessels:

1. Safety.
2. Fuel consumption penalty (hence range, fuel cost, carbon dioxide emissions and power penalties).
3. Installation, maintenance and operating costs.
4. Implementation risk.
5. Vulnerability.
6. System volume.
7. System weight.
8. Operational logistical support and maintenance requirements.
9. Operating environment.
10. Commonality across different ships.

To simplify the analysis, this list was shortened by combining similar design drivers and excluding variables that were not likely to discriminate effectively between different solutions. System safety, vulnerability (in general terms) and ability to operate in a demanding operating environment were considered to be too complicated to systematically assess for each of the potential solutions so were not included in my quantitative analysis. The advantages of system commonality are best applied when interpreting results so this was also not included in the quantitative assessment.

The effect of system choice on exhaust temperatures and ship's Infra-Red (IR) signature has a significant and readily quantifiable effect on ship vulnerability. Effect of system choice on IR signature was, therefore, included in the quantitative analysis. Fuel consumption penalty, maintenance and operating costs were combined into a single 'Running cost' metric. The importance of system volume and weight were assessed to be very similar for naval ships so these were also combined. These design drivers were used to inform the assessment in the 'Analysis' section.

Different ship types can be grouped by potential solution by graphically plotting them by the importance of the design drivers which most effectively discriminate between different system choices. In this case, it was assessed that costs and risk are similarly important for different types of ship. The importance of volume, weight and logistical requirements were considered to vary significantly between different ship types. Figure 1 therefore shows a range of naval platforms plotted against quantitative estimates of the relative importance of a combined weight and volume metric versus the relative difficulty of logistical support. Ships for which the IR signature is highly important are labelled with an asterisk. Possible groupings of different ships by potential solution are shown.




SSN: Fleet submarine
SSBN: Ballistic missile submarine
LCVP: Landing Craft Vehicle and Personnel
MCM: Mine Counter-Measures vessel
LCU: Landing Craft Utility
LPD: Landing Platform (Dock)
OSV: Ocean Survey Vessel
MPSV: Multi-Purpose Survey Vessel
LSD(A): Landing Ship (Auxiliary)
LPH: Landing Platform (Helicopter)
AC: Aircraft
OPV: Offshore Patrol Vessel
APV: Antarctic Patrol Vessel
* IR signature highly important
G: Diesels likely to be fitted for slower speeds and electrical power generation only

*Figure 1: Possible groupings of vessels by potential solution. Relative importance of weight, volume and logistical support design drivers for different ship types. The marks vary from low importance (1) to high importance (9)*

## TECHNICAL DESCRIPTION AND QUALITIES OF $NO_x$ REDUCTION TECHNOLOGIES

### $NO_x$ Formation in Diesel Engines

Combustion engine $NO_x$ emissions consist of a mixture of NO and $NO_2$. $NO_2$ forms a significant

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proportion of the total $NO_x$ in the vicinity of the flame in gas turbine and external combustion engines; however the concentration in the exhaust of diesel engines is much lower because $NO_2$ removal reactions are rapid and occur readily in the cylinder before gas is expelled by the exhaust stroke [24]. As a result, NO makes up 90 to 99% of the total diesel exhaust $NO_x$ [25] [26]. To meet Tier III legislation it is, therefore, appropriate to focus on NO as the main problem. Methods to reduce or eliminate $NO_x$ emissions from diesel engines are either through reducing the temperature of combustion (on-engine techniques) or by treating the exhaust gases to remove $NO_x$ (after-treatment techniques), which are discussed here in detail.

**On-Engine Techniques**

Water Injection (Figure 2)

Water inclusion incorporates several different techniques including ‘Direct Water Injection’, ‘Fuel-Water Emulsion’, ‘Humid Air Motor’ and ‘Intake Water Injection’. The intention with each is to reduce the cylinder temperature [6] by increasing the quantity of water present in the cylinder. All of these options, however, use a very large volume of desalinated water or occupy an unacceptably large hull volume [27] [10] and are not appropriate for warships.

Exhaust Gas Recirculation (Figure 3)

Exhaust Gas Recirculation (EGR) works by returning a proportion (typically 20%) of exhaust gas back to the inlet. This leads to a reduction in the peak cylinder temperature, reducing $NO_x$ production by up to 50%, because the exhaust gas contains water vapour and a reduced concentration of oxygen [28]. For high-speed and low-speed engines EGR can sufficiently reduce $NO_x$ concentrations to comply with Tier III [17] [15], however for medium-speed marine engines reduction has not been sufficient for Tier III compliance [29].

EGR is associated with a rise in PM, CO and hydrocarbon (HC) emissions; although with 20% re-circulation it has been argued that these are not problematic [30] [31]. It occupies machinery space volume, however systems are typically integrated with the air supply system to slightly increase the size of the engine [17]. Water to cool the recirculating exhaust gases can be supplied from a slightly larger engine coolant system. This approach minimises the hull volume requirements of the system.

EGR is a mature technology for various land-based applications [15]. No specific problems have been identified for its use at sea and it is considered to be a relatively low-risk technology. The system is largely a self-contained unit in the vicinity of the engine and its cost is likely to be relatively low. There is minimal consumption of power or consumable fluids, so the running cost is likely to be low.

**After-Treatment Systems**

Conventional Selective Catalytic Reduction (SCR)

In conventional SCR systems, ammonia ($NH_3$) is used as a reductant to convert $NO_x$ to nitrogen and water. Ammonia is difficult to store, so it is usually carried as aqueous solution of urea ($CO(NH_2)_2$). This solution is injected into the hot exhaust stream, which is maintained between 300°C and 400°C to facilitate sufficient reaction rate whilst preventing the urea or ammonia from burning in the presence of oxygen. The urea rapidly decomposes and reacts with engine exhaust water to produce ammonia and carbon dioxide [6] [19]:

$$CO(NH_2)_2 + H_2O \rightarrow 2\,NH_3 + CO_2 \qquad (1)$$

The ammonia then combines with nitrogen oxides and oxygen to produce non-toxic nitrogen and water which are exhausted to the atmosphere. A catalyst

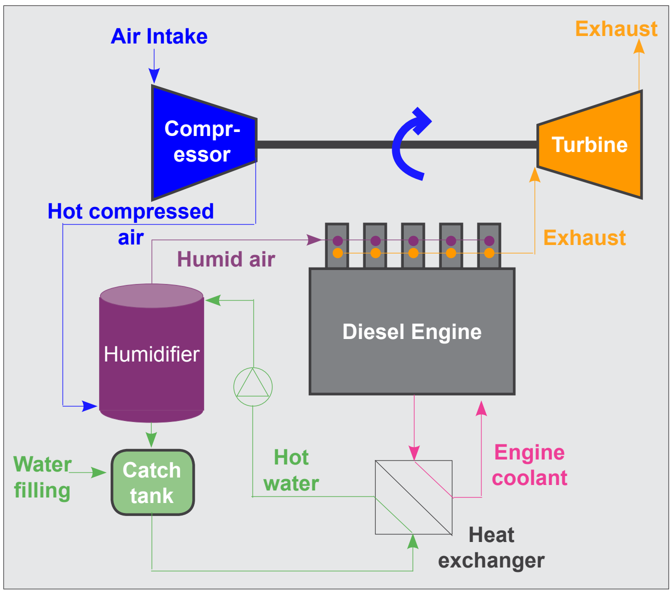


*Figure 2: Water Injection – Humid Air Motor*

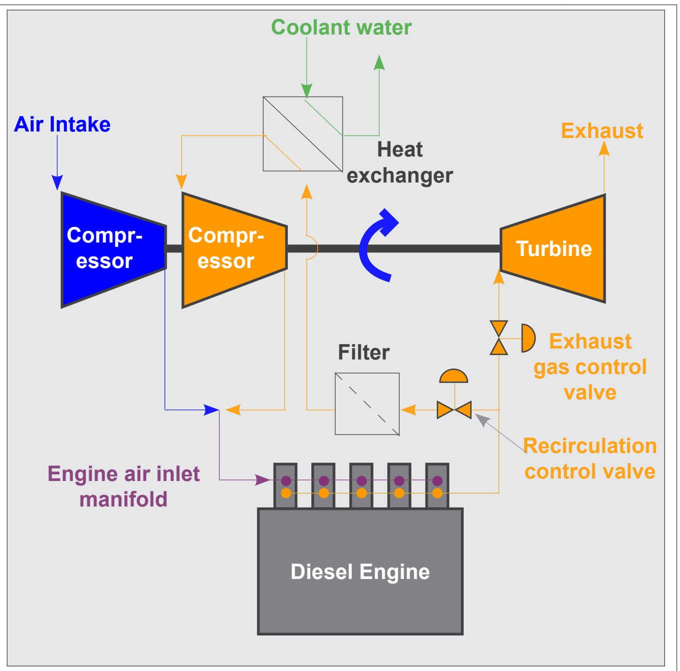


*Figure 3: Exhaust Gas Recirculation*

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such as platinum is used to maximise $NO_x$ conversion for minimal $NH_3$ consumption [32]:

$$4\ NH_3 + 4\ NO + O_2 \rightarrow 4\ N_2 + 6\ H_2O \quad \textbf{(2)}$$
$$2\ NH_3 + NO + NO_2 \rightarrow 2\ N_2 + 3\ H_2O \quad \textbf{(3)}$$
$$8\ NH_3 + 6\ NO_2 \rightarrow 7\ N_2 + 12\ H_2O \quad \textbf{(4)}$$

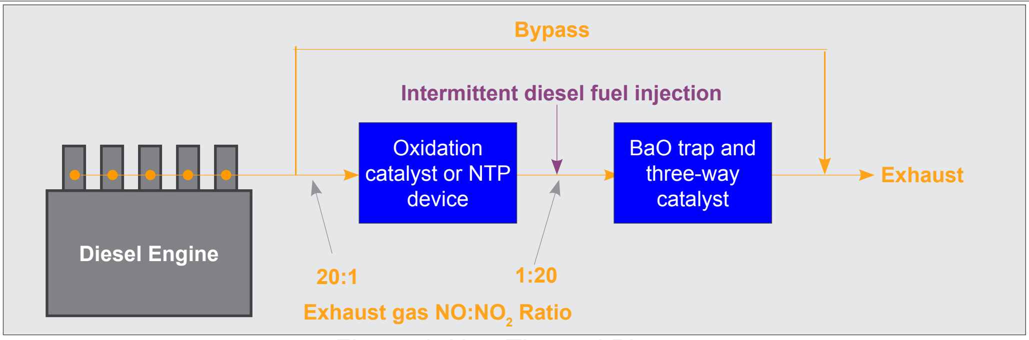


*Figure 4: Non-Thermal Plasma*

This process is more effective at removing NO than $NO_2$ because reaction **(2)** occurs more readily than **(4)** [33], and so it is counterproductive to combine urea-SCR with pre-treatment that converts NO to $NO_2$.

The urea consumption of this system is approximately 8.5% of the consumption of diesel fuel. A 5000 tonne escort is likely to carry approximately 600 m³ of fuel oil. For continuous operation using urea-SCR in a $NO_x$-restricting ECA without reducing the range of a ship like this, approximately 50 m³ of urea solution would be required. This fluid plus the tank and transfer systems would add significantly to the ship's weight, reducing operational capability and increasing capital and operating costs.

Tier III $NO_x$ limits have been aligned to the significant (>95% [34]) reductions that are achievable using SCR [8]. SCR systems are commercially available from a range of manufacturers, including MAN, Wärtsilä, MTU and Mitsubishi [19] [20] [22] [35], and they have been successfully fitted to a wide variety of ships, including six patrol vessels of the Royal Danish Navy [36]. Urea-SCR systems for $NO_x$ removal are a mature technology and represent a low level of technical risk. It is assumed that the moderately sized, moderately complex systems using a platinum catalyst represent a moderate to high capital cost. A volumetric gas flow to catalyst volume ratio of 8.3 [s-1] for a 182 [ppm] $NO_x$ feed has been quoted [34]. High consumable use and routine catalyst replacement are likely to lead to high running costs.

<ins>Non-Thermal Plasma (NTP)</ins> (Figure 4)

NTP techniques introduce a pulsed electron plasma into the exhaust gas. This generates reactive radicals, such as ozone ($O_3$) and atomic oxygen (O), without significantly increasing the gas temperature [26]. These radicals promote the breakdown of toxins (including $SO_x$, $NO_x$, PM and hydrocarbons) in the exhaust gas [37]. The oxygen radicals act to effectively oxidise NO to $NO_2$ [38]:

$$3\ O + NO \rightarrow NO_2 + O_2 \quad \textbf{(5)}$$
$$O_3 + NO \rightarrow NO_2 + O_2 \quad \textbf{(6)}$$

Removal of NO from the exhaust can exceed 99.5% [39]. $NO_2$ cannot, however, be effectively oxidised to molecular nitrogen and oxygen, so the $NO_2$ concentration increases [40]. NTP is an area of interest because $NO_2$ can be more readily removed from the exhaust stream than NO using methods including further oxidation in the presence of a hydrocarbon reductant [41] [34] [42] [43], dissolution and removal in a liquid medium [38] [44] and catalytic reduction techniques such as Lean $NO_x$ traps [45].

NTP devices for NO to $NO_2$ conversion are at a technology demonstration stage and represent a moderate level of technical risk. It is assumed that the small, mechanically simple systems represent a low capital cost and that minimal consumable and low power usage will lead to low running costs.

<ins>Hydrocarbon SCR</ins> (Figure 5)

Hydrocarbons, including those which constitute diesel fuel, can also be used as a reductant in an SCR process. Disappointing results have been obtained by directly spraying diesel fuel HCs into the exhaust, but oxygenated hydrocarbons (OHCs) and HC combined with NTP have proved more promising [45]. Oxygen radicals can be generated using NTP which, when mixed with the hydrocarbons which constitute diesel fuel, produce OHCs. These are then combined with the exhaust stream, in the presence of a catalyst, to eliminate $NO_2$. The

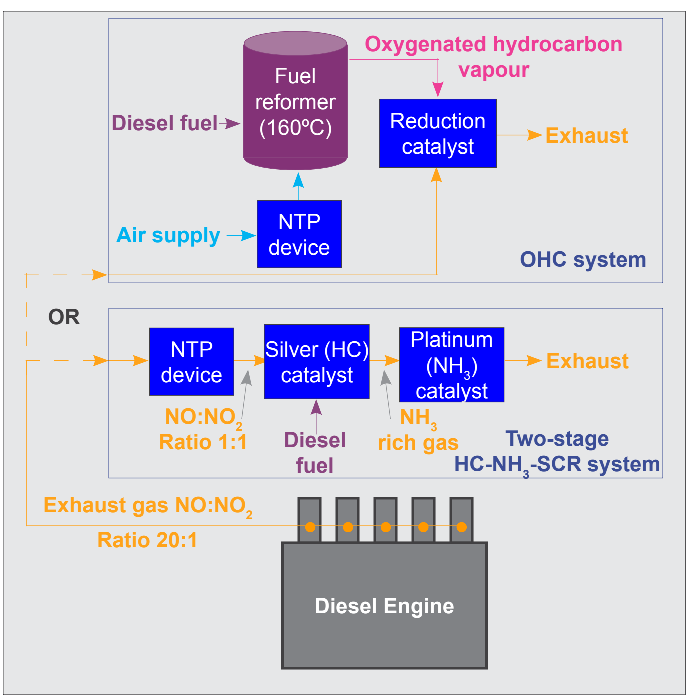


*Figure 5: Hydrocarbon-SCR*

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processes can be summarised as follows [34]:

$$3\ O_2 + e^- \rightarrow 2\ O_3 + e^- \quad \textbf{(7)}$$
$$NO + O_3 \rightarrow NO_2 + O_2 \quad \textbf{(8)}$$
$$HC + O_3 \rightarrow OHC + O_2 \quad \textbf{(9)}$$
$$NOx + OHC + catalyst \rightarrow N_2 + H_2O + CO_2 + catalyst \quad \textbf{(10)}$$

Complex reactions of OHCs with exhaust gases also result in the formation of $N_2O$ and $NH_3$. $N_2O$ is a greenhouse gas with a 100-year global warming potential 298 times greater than $CO_2$. [46] $NH_3$ is a human irritant and is dangerous to the environment [47].

An alternative approach is to use a two-stage HC-SCR and $NH_3$-SCR. The first stage is optimised to produce $NH_3$, which is then used with a conventional platinum catalyst (as used with urea-SCR) to further reduce $NO_x$ [48]. This has achieved promising results using an exhaust stream NO:$NO_2$ ratio of 1:1; because real diesel exhaust streams contain much more NO, it is likely that an NTP device would be needed upstream of the two-stage catalyst to achieve a satisfactory system performance.

Additional fuel consumption here is less predictable than the reductant consumption of urea-SCR systems. To avoid a reduction in the ship's range, the additional fuel requirement could be between half (hypothesised potential) and twice (for a current test system) the urea tank volume for a urea-SCR system.

Where an external fuel reformer or NTP device is used the system (excluding reductant) will have a greater volume than urea-SCR. Volumetric gas flow to catalyst volume ratios of between 1.8 and 8.3 s-1 for 182 to 200 ppm $NO_x$ feeds have been quoted, the high end of which is similar to urea-SCR [34] [48]. These fuel reformers operate with diesel fuel at between 140°C and 160°C and at these temperatures the fuel vapour will ignite readily [34], posing significant safety challenges for RN ships. Noble metal catalysts are not required so the catalyst matrix in the exhaust stream is likely to be less expensive than with urea-SCR [34]. Where NTP is not used, higher temperatures of 375°C to 425°C are required for adequate conversion rates [48]. In this case, it may be necessary to heat the exhaust gases to facilitate efficient operation. This will system increase size, power consumption and IR signature when the system is in use.

Practical marine HC-SCR systems are at an early stage of development and constitute a high level of technical risk. The moderate system size and complexity is likely to result in a moderate acquisition cost and the low to moderate reductant (diesel) consumption penalty and possible requirement for catalyst replacements will lead to moderate operational costs.

<u>Dissolution in a Liquid Medium</u>
(Figure 6)

Scrubbers are a common method of removing $SO_x$ from diesel exhausts. These work by dissolving sulphur oxides in seawater [10]. NO has a low solubility in seawater so this approach is largely ineffective at reducing $NO_x$ concentrations. However, $NO_2$ readily hydrolyses in water to give nitrous and nitric acids [44]:

$$2\ NO_2 + H_2O \rightarrow HNO_2 + HNO_3 \quad \textbf{(11)}$$

By first converting NO to $NO_2$, $NO_x$ can be removed from the exhaust stream. The conversion is most effectively conducted using NTP and this overall process is termed 'Wet NTP' [11].

The process of $NO_2$ hydrolysis is accelerated by the presence of a base such as $NH_3$ or sodium sulphite in solution, which prevents saturation of the removal liquid by nitrate ($NO_3^-$) and nitrite ($NO_2^-$) ions [44]. This requires a significant volume of base to be carried on board. Much of the recent research has focussed on the use of these, especially where a combined NTP and dissolution device is used [38] [39] [44].

For ships it is more practical to avoid acid saturation of the removal liquid by increasing the volume flow rate of sea water. This method has been shown to be effective: Ecospec [28] market a scrubber that removes around 66% of $NO_x$ whilst Balon and Clark [49] project that 90% $NO_x$ removal is feasible by scaling up their system. Both of these used a two-stage oxidation and dissolution process.

These scrubber systems also remove $SO_x$, PM, HCs and some $CO_2$ from the exhaust. All of these processes result in significant acidification of the operating liquid, and pumping this directly overboard poses significant local marine pollution and global ocean acidification problems. Storing the liquid on board is impractical for a densely packed warship and the usual approach is to neutralise it with an alkaline injector or dilute it with additional seawater until it is has a pH greater than 6.5 [15].

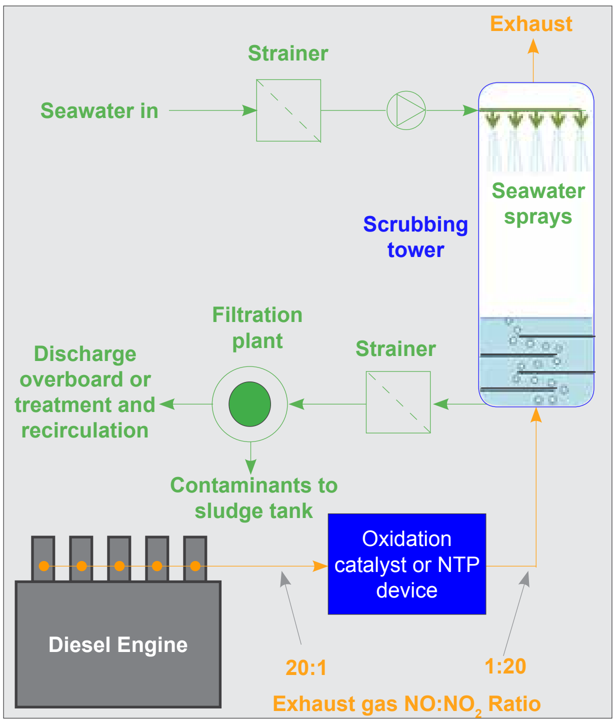

*Figure 6: Dissolution in a Liquid Medium*

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The power consumption of a catalyst-scrubber or wet-NTP system is likely to be quite small, equating to a fuel penalty of approximately 1-2%. It would require a relatively small storage tank of an alkaline substance to facilitate $NO_x$ destruction or neutralisation of wash-water discharge and a 'sludge tank' for the storage of substances that should not be discharged to the sea. The space requirement in the engine rooms and funnel is likely to be very significant: the system would require additional circulation pumps, substantial piping, an alkaline dosing, dilution system or $NO_x$ destruction system, NTP or a catalytic converter and a very large dissolution 'tower' [49].

Using a dissolution system will significantly cool escaping exhaust gases, reducing the ship's IR signature. The large volumes of water that will need to be pumped around the ship, especially if dilution water is used, would increase the vessel's damage vulnerability through the potential for internal flooding from system pipework. Whilst in operation, the acoustic signature would also be increased through the associated mechanical noise and cavitation in pumps and pipes.

Dissolution systems for $NO_x$ removal are at a technology demonstration stage and represent a moderate level of technical risk. It is assumed that the large, complex systems represent a high capital cost but that low consumable and power uses will lead to low running costs.

<u>Lean $NO_x$ Traps</u>

Lean $NO_x$ Traps (LNTs) work in two stages. First, NO is oxidised to $NO_2$ in the presence of a catalyst (which is usually platinum) [43] [50]:

$$2NO + O_2 \rightarrow 2\ NO_2 \qquad \textbf{(12)}$$

The $NO_2$ is then transferred to a nearby 'trap' material such as barium oxide (BaO) where it is stored as nitrates including barium dinitrate $Ba(NO_3)_2$:

$$4\ NO_2 + 2\ BaO + O_2 \rightarrow 2Ba(NO_3)_2 \qquad \textbf{(13)}$$

Hydrocarbons are intermittently supplied to the exhaust volute to create a fuel-rich, carbon monoxide (CO)-rich environment as the hydrocarbons are partially oxidised in the oxygen-depleted exhaust gases. For example, where *a*, *b*, *x*, *y* and *z* are variable but *x* is significant in comparison with *y*:

$$a\ C_{12}H_{23} + b\ O_2 \rightarrow x\ CO + y\ CO_2 + z\ H_2O \qquad \textbf{(14)}$$

The process of increasing CO concentration can also be promoted by using a high EGR ratio. Under these conditions the nitrate species are thought to become unstable, due to the reduced oxygen concentration in the surrounding gases [43], and decompose to BaO, NO and $O_2$:

$$2\ Ba(NO_3)_2 \rightarrow 2\ BaO + 4\ NO + 3\ O_2 \qquad \textbf{(15)}$$

The nitrogen oxide then reacts over a conventional automotive three-way catalyst (such as rhodium) with CO to produce $N_2$ and $CO_2$ which (along with $H_2O$) are the only overall products:

$$2\ NO + 2\ CO \rightarrow N_2 + 2\ CO_2 \qquad \textbf{(16)}$$

The use of platinum could be avoided by using an NTP device upstream of the catalyst, feeding $NO_2$ directly to the BaO 'trap'.

LNT systems have been shown to achieve reductions of at least 75% in the 330°C to 440°C temperature range, rising to nearly 90% at optimum temperatures [29] [51]. Tenneco are marketing a commercial version for large road vehicles which achieves a 60% $NO_x$ reduction using a diesel fuel feedstock with a 350°C catalyst temperature [52].

The performance of LNT catalysts is greatly reduced by sulphur contamination, even at the sulphur levels present in 'low-sulphur' fuel. Sulphur traps are being developed that can protect the catalysts, however these take up volume, can be expensive and require replacement several times through the life of the engine. If the ship is required to operate with fuel that has a higher sulphur content than F-76, then it is likely that degradation of the catalyst would occur [45]. This is likely to mean that an exhaust gas bypass system and/or method to intermittently heat the trap to around 700°C for desulphurisation would be required.

Assuming that LNT systems are able to operate, as is predicted, with a 4-6% fuel penalty then the system is likely to require a similar additional volume of fuel as HC-SCR to maintain the same ship range. It is likely that the LNT catalyst could fit into the same volume as, and replace, the conventional silencer. Some additional space would be required in the funnel for a desulphurisation heater or bypass silencer.

LNT systems for $NO_x$ removal are at an early implementation stage for non-marine applications and therefore represent a moderate level of technical risk. It is assumed that the relatively simple systems represent a moderate to low capital cost. A volumetric gas flow to catalyst volume ratio of 8.3 s-1 for a 200 ppm $NO_x$ feed has been effective; this is the same as that quoted for urea and HC-SCR systems [50]. Moderate consumable use, low power use and the probable requirement for catalyst replacement are likely to lead to moderate to low running costs.

## CRITICAL ANALYSIS

### Selection of Potential Solutions

The range of potential solutions to the problem of reducing $NO_x$ emissions from future RN ships is highly complex and the number of permutations is increased by the potential to install various combinations of different technologies. In order to conduct a meaningful comparative analysis it is necessary to narrow the assessment to a reasonable

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number of promising permutations that can achieve a reduction in $NO_x$ emissions of approximately 75% from Tier II levels, as explained in Section 1.

### Non-Diesel Solutions

Nuclear propulsion has been proposed as a suitable power source for aircraft carriers, however the expected hull life of the Queen Elizabeth class of aircraft carrier means that further hulls are unlikely to be built before 2060 [53] [54]. Gas turbines and advanced gas turbines are widely used for marine propulsion and electrical generation. They do offer a realistic alternative to diesel generators, especially for compact, short-range vessels [55]. These are, therefore, included as options in this analysis.

### Exhaust Gas Recirculation

EGR has the potential to significantly reduce $NO_x$ emissions without fuel consumption penalty or use of consumable fluids. It also occupies a relatively small volume. Although it will not satisfy Tier III alone, it has the potential to reduce the required capacity of an after-treatment system. The increased CO and HC output can improve the performance of HC-SCR and LNT after-treatment techniques. After-treatment systems will, therefore, be considered both with and without EGR fitted to the engine.

### After-Treatment Systems

The following after-treatment systems have been investigated and offer potential to satisfy Tier III restrictions for RN ships:

1. Urea-SCR.
2. NTP followed by OHC-SCR.
3. NTP followed by HC-SCR and $NH_3$-SCR.
4. NTP followed by $NO_2$ dissolution.
5. LNT.

These are all associated with cost, volume, risk and logistical penalties and have varying IR performance. Each are included as options for this assessment, both alone and in conjunction with EGR, using the system numbers designated in Table 1.

### Analysis Methodology

Decision making in complex engineering design projects is commonly informed by the weighted matrix method. A matrix containing numbers representing the qualities of different systems is multiplied by a second matrix representing the relative importance of these qualities to a range of different applications. This produces a results matrix representing the relative suitability of each solution to each application [56].

This method was used to assess the suitability of each of the 12 solutions for a range of vessel types. Six vessel requirements/ system qualities used for the assessment were:

1. Capital and installation cost.
2. Running cost.
3. Implementation risk.
4. Volume and weight.
5. Logistical requirement.
6. IR signature effect.

These were all ascribed different weightings for different ship types as shown in Table 2. Because a contemporary assessment of ‘implementation risk’ is included in this analysis, the results described here represent the relative suitability of different design solutions shortly after 2016. These risks, and therefore the optimal solutions, will change as the technologies are matured.

The vessels investigated were chosen by inspection of Figure 1. These included one in the centre and two at the extremities of each of the ‘commercial solutions may be acceptable’ and ‘primary area

| Option | NO reduction | NO to $NO_2$ conversion | $NO_2$ removal |
|---|---|---|---|
| 1 | gas turbine | - | - |
| 2 | adv. gas turbine | - | - |
| 3 | - | urea-SCR | urea-SCR |
| 4 | - | NTP | OHC-SCR |
| 5 | - | HC-SCR | $NH_3$-SCR |
| 6 | - | NTP | dissolution |
| 7 | - | catalysis | LNT |
| 8 | EGR | SCR | SCR |
| 9 | EGR | NTP | OHC-SCR |
| 10 | EGR | HC-SCR | NH3-SCR |
| 11 | EGR | NTP | dissolution |
| 12 | EGR | catalysis | LNT |

*Table 1: NOx abatement system option numbers – see Table 3 and Figure 3*

| Ship type | Replenishment | Sealift | Landing Ship Dock (Auxiliary) | Landing Platform (Dock) | Medium Escort[a] | Landing Craft Vehicle & Personnel | Antarctic Patrol Vessel | Hovercraft | Patrol Boat |
|---|---|---|---|---|---|---|---|---|---|
| Design Driver | | | | | | | | | |
| Capital & inst. cost | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Running cost | 6 | 6 | 6 | 6 | 6 | 5 | 6 | 4 | 6 |
| Risk | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Volume & weight | 3 | 1 | 3 | 4 | 6 | 8 | 3 | 8.5 | 8 |
| Logistical rqmt. | 2 | 1 | 4 | 5 | 7 | 6 | 8 | 9 | 2 |
| IR signature effect | 3 | 1 | 4 | 5 | 6 | 7 | 1 | 4 | 7 |

a: Diesels assumed to be for electrical power and slower speed propulsion only.

1: Low design driver importance, 9: High design driver importance

*Table 2: Relative Importance of Design Drivers for Various RN Ship Types*

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of interest for naval ship solutions' areas, plus two outliers:

1. Replenishment ship.
2. Sealift ship.
3. Landing Ship Dock (Auxiliary).
4. Landing Platform (Dock).
5. Medium escort.
6. Landing Craft Vehicle and Personnel.
7. Antarctic Patrol Vessel.
8. Hovercraft.
9. Patrol boat.

A 12 x 6 matrix of the qualities of each technology was generated (T, Table 3) , the rows of which contained relative quantitative estimates of the performance of each solution against the design drivers (in the columns) as listed above. A second matrix of the estimated relative importance of the same design drivers (the rows) for a range of vessels (V, of size 6 x 6, Table 2) was also produced. These were then multiplied together to produce a results matrix (R), containing scores representing the relative suitability of the different solutions for each vessel type:

$$R = TV \qquad \textbf{(17)}$$

**Sensitivity**

An indication of sensitivity of the most appropriate system can be gained by comparison of the relative suitability scores of different abatement systems for a particular ship. Where scores are similar, more detailed assessment is necessary to determine the optimal solution. Where there is a score that is clearly greater than the others then it is highly likely that this is the most suitable technology.

A high level of importance has been given to minimising system volume and weight, so the 'volume and weight' performance of each abatement system was therefore determined in a detailed quantitative assessment. As a result of this analysis there is a good level of confidence in these values.

Estimates of implementation risk, logistical requirement and IR signature effect are approximate. A good level of information about these has been available in the literature and, therefore, the uncertainty relating to these values is assessed to be quite low.

## RESULTS AND DISCUSSION

The results matrix R consists of rows representing the relative suitability of different abatement systems for the ships represented in the columns. Graphical plots of the relative scores contained in these columns are useful to identify promising solutions. The scores of different abatement systems for various ships (grouping ship types by their proximity in Figure 1) are shown in Figure 7 (opposite). For a given ship type, the most promising systems are those with the highest scores on the vertical axis. These vessel types are grouped together in Figure 8 (opposite) to allow commonality across the fleet.

For the lower capability sealift and replenishment vessels shown in Figure 7(a), urea-SCR (Option 3) represents a sensible option because it is associated with low implementation risk and the weight, volume, logistical and IR signature problems associated with this technology are of lesser concern. For the more capable LSD(A) and LPD, the disadvantages of SCR become more significant than the risk associated with other technologies. In both of these cases the best option is EGR $NO_x$ reduction followed by LNT $NO_x$ destruction (Figure 7(a), Option 12). This implies that the area of Figure 1 that was labelled as 'commercial solutions may be acceptable' is too large and that these two ship types actually belong in the 'warship' area.

The solid box in Figure 8 shows those ships for which urea-SCR (Option 3) is probably the most effective option for 2016 implementation. Other strong contenders for fitting to these ships are EGR followed by a smaller SCR system (Option 8), LNT (Option 7)) and EGR in combination with LNT (Option 12).

For the higher capability warships shown in Figure 7(b) and (c), urea-SCR (Options 3 & 8) becomes highly uncompetitive. For all of these ships, EGR followed by a LNT system (Option 12) receives a strong relative score based upon its relatively low system volume and minimal logistical requirements. The combination of reducing $NO_x$ formation and after-treatment reduces the risk that the system will not meet Tier III limits. The large dashed box in Figure 8 represents the range of vessels for which EGR-LNT probably represents the best option. Other competitive systems for these vessels that have very similar scores, and therefore warrant serious consideration, are LNT without EGR (Option 7) and EGR with NTP and two-stage HC then $NH_3$–SCR (Option 10).

| Option # | Capital & inst. cost | Running cost | Risk | Volume and weight | Logistical requirement | IR signature |
|---|---|---|---|---|---|---|
| 1 | 4 | 1 | 8 | 1 | 7 | 3 |
| 2 | 1 | 5 | 3 | 8 | 9 | 7 |
| 3 | 5 | 6 | 9 | 7 | 1 | 5 |
| 4 | 7 | 7 | 1 | 6 | 7 | 5 |
| 5 | 7 | 7 | 1 | 9 | 8 | 5 |
| 6 | 6 | 8 | 1 | 3 | 3 | 8 |
| 7 | 7 | 6 | 3 | 8 | 9 | 5 |
| 8 | 4 | 6 | 8 | 8 | 2 | 5 |
| 9 | 6 | 7 | 2 | 7 | 8 | 5 |
| 10 | 6 | 7 | 2 | 9 | 9 | 5 |
| 11 | 5 | 8 | 2 | 6 | 4 | 8 |
| 12 | 6 | 6 | 4 | 9 | 9 | 5 |

1: Very poor system performance, 9: Very good system performance

*Table 3: Relative Qualities of Abatement Systems (see Table 1 above)*

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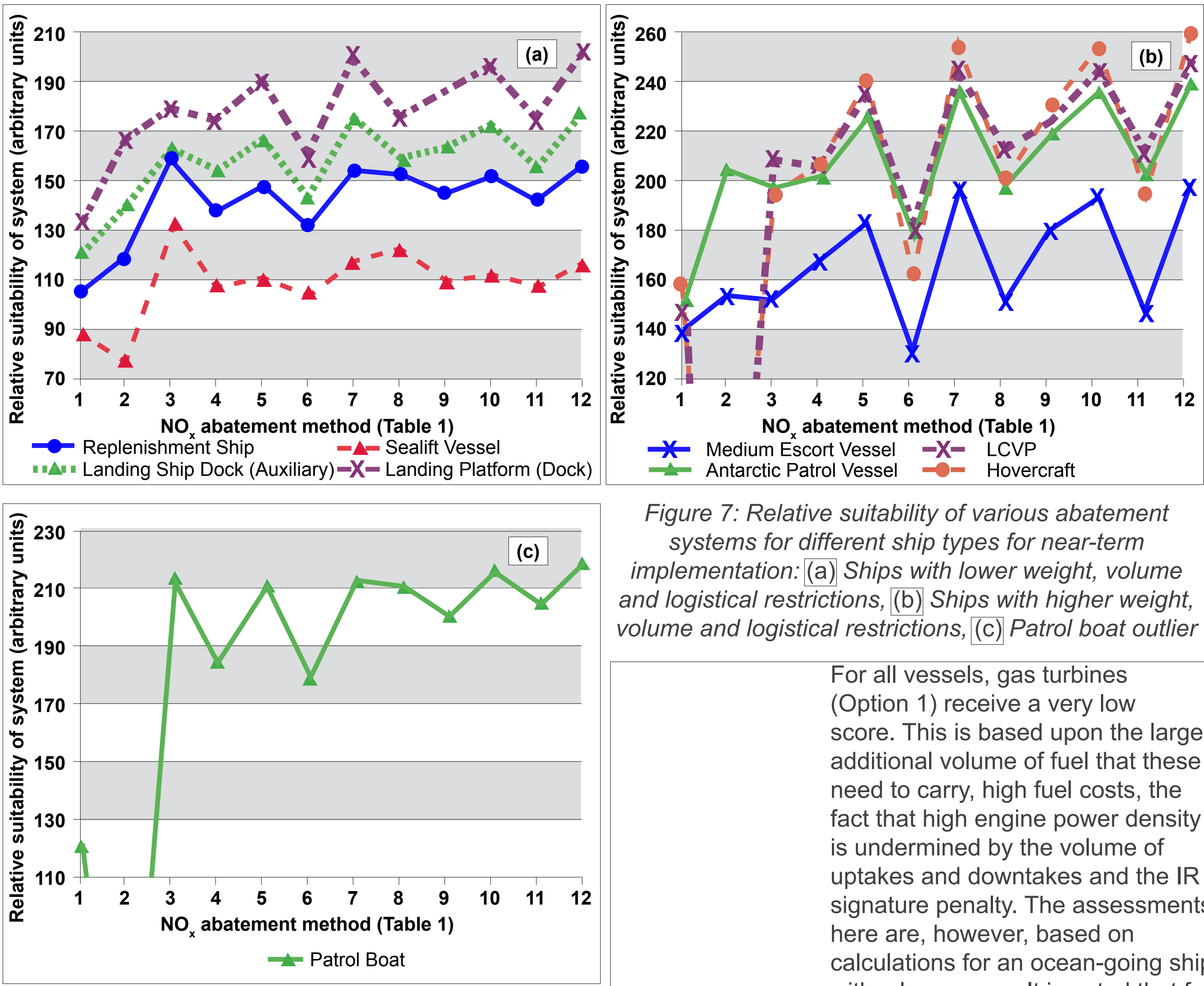


*Figure 7: Relative suitability of various abatement systems for different ship types for near-term implementation: (a) Ships with lower weight, volume and logistical restrictions, (b) Ships with higher weight, volume and logistical restrictions, (c) Patrol boat outlier*

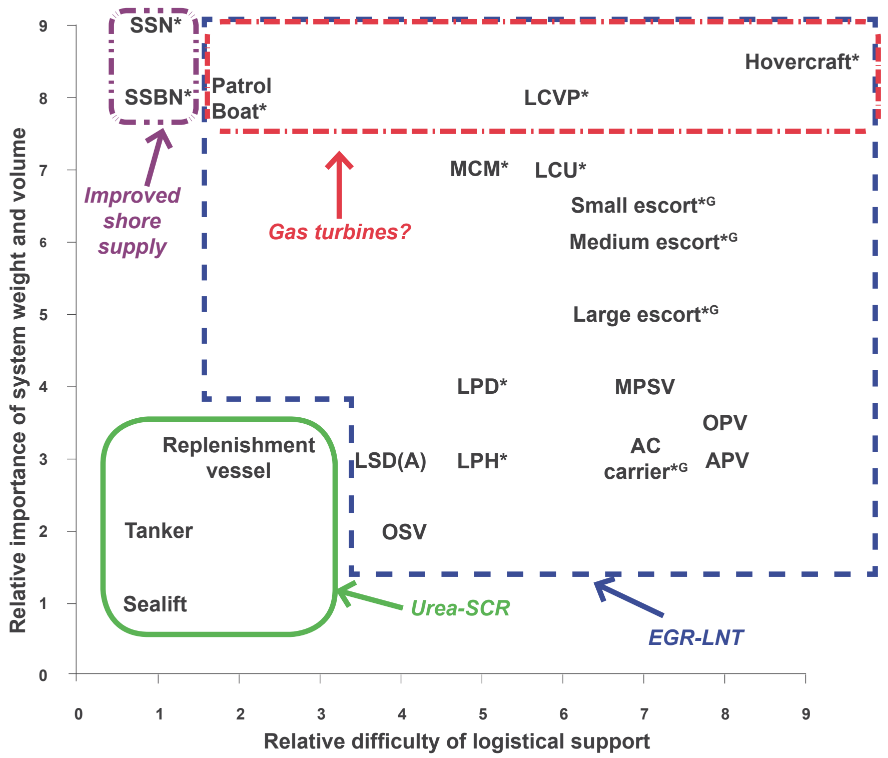


*Figure 8: Grouping of vessel type by optimal $NO_x$ abatement method for near-term implementation*

For all vessels, gas turbines (Option 1) receive a very low score. This is based upon the large additional volume of fuel that these need to carry, high fuel costs, the fact that high engine power density is undermined by the volume of uptakes and downtakes and the IR signature penalty. The assessments here are, however, based on calculations for an ocean-going ship with a long range. It is noted that for small, shorter-range vessels, such as landing craft, hovercraft and patrol boats, the fuel volume penalty may be less important than the benefits of increased power density. This is argued based upon more comprehensive assessment by Buckingham et al [55]. The smaller box bordered by the dashed-dotted line in Figure 8 shows those vessels for which gas turbine prime movers should be given serious consideration.

Patrol boats form an outlier in Figure 1 and are also shown in Figure 7(c). EGR followed by NTP then $NO_x$ dissolution (Option 11) scores quite highly for these ships, partly because of the improved IR signature associated with a system including a dissolution element. EGR-SCR (Option 8) also seems to be an attractive option because its logistical challenges are less significant for these vessels. EGR-LNT (Option 12) appears

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to represent the best option and this would also permit greater commonality across the future fleet.

## CONCLUSIONS, RECOMMENDATIONS AND EVALUATION

I have described the implications of future IMO discharge policies on designing future RN ships. The constraints placed on RN ships are different from those on the civilian fleet: resilience, vulnerability, logistics and maintenance and system volume and weight. A weighted-matrix approach was applied to see how technologies match ship type, classified broadly by volume and logistical complexity. This analysis provides a view on the near term technology solutions, based on the present state of technology development.

For lower-capability ships such as replenishment vessels, urea-Selective Catalytic Reduction systems are appropriate because they minimise implementation risk. For the majority of RN vessels, Lean $NO_x$ traps are most suitable because the system size and logistical benefits are likely to outweigh the implementation risks. The use of Exhaust Gas Recirculation in conjunction with lean $NO_x$ traps should permit a significant reduction in system size. All three of these technologies have already been proven in different applications and their use in combination represents a relatively achievable route to legislative compliance. Gas turbines may be the most appropriate option for small, densely packed vessels such as hovercraft, landing craft and patrol boats and should be investigated on a case-by-case basis.

The criteria applied to find the optimal abatement strategy for mitigating $NO_x$ release and meeting legislative targets do not include a detailed cost assessment. Future work should be centred around this as it will improve the accuracy of the system selection recommendations that can be made using the processes described here. Other factors that require finer detail of specific technologies include investigation of redundancy, failure analysis, shock and vibration performance, intellectual property restrictions and training matters.

### GLOSSARY OF TERMS

| | |
|---|---|
| EGR | Exhaust Gas Recirculation |
| HC | Hydrocarbons |
| IMO | International Maritime Organisation |
| IR | Infra-Red |
| LNT | Lean NOx Traps |
| MARPOL | Marine Pollution |
| NOx | Nitrogen Oxides |
| SOx | Sulphur Oxides |
| PM | particulate matter |
| NTP | Non-Thermal Plasma |
| OHC | Oxygenated Hydrocarbons |
| SCR | Selective Catalytic Reduction |

## REFERENCES


[1] EPA. (2012) United States Environmental Protection Agency. [Online]. www.epa.gov/air/nitrogenoxides

[2] IMO. (2011) International Maritime Organisation. [Online]. www.imo.org/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Air-Pollution.aspx

[3] IMO, *MARPOL Consolidated Edition*. Croydon: CPI, 2011.

[4] E. Hughes, *More environmental challenges to come*, Lloyd's List, p. 6, October 2011.

[5] DE&S Platform Systems Group, *Headline Science and Technology Needs* [Spreadsheet], 2011.

[6] S. Venkatesh, *Reduction of $NO_x$ and PM from Navy Diesel Engines*, Mountain View, 1996.

[7] D. Hughes, *Diesel Emissions: 2000 and Beyond: a Naval Perspective*, Journal of Naval Engineering, vol. 39, no. 3, pp. 389-396, 2001.

[8] D. Hughes, *Diesel Emissions: A Royal Navy Approach*, Journal of Naval Engineering, vol. 45, no. 3, 2001.

[9] R. English and D. Swainson, *The Impact of Engine Emissions Legislation on Present and Future Royal Navy Ships*, Journal of Naval Engineering, vol. 35, no. 2, pp. 334-344, 1994.

[10] Z. Yang et al., *Selection of techniques for reducing shipping $NO_x$ and $SO_x$ emissions*, Transportation Research Part D, vol. 17, pp. 478-486, 2012.

[11] V. Pettersson and E. Thune, *Failure Modes and Effects Associated with Installing and Operating Abatement Technologies for the Reduction of $NO_x$ and $SO_x$ Emissions on Board Ships*, Gothenburg, 2011.

[12] B. Lin and C. Lin, *Compliance with international emission regulations: Reducing the air pollution from merchant vessels*, Marine Policy, vol. 30, pp. 220-225, 2006.

[13] K. Reynolds, *Exhaust Gas Cleaning Systems Selection Guide*, Seattle, 2011.

[14] S. Solem, O. Balland, K. Fagerholt, and S. Erikstad, *Designing Ship Machinery Systems Towards Future Air Emission Regulations*, in 11th International Marine Design Conference, Glasgow, 2012, pp. 225-236.

[15] Lloyd's Register, *Understanding exhaust gas treatment systems*, London, 2012.

[16] CCA. (2005) Combustion Components Associates. [Online]. www.cca-inc.net/sncr.htm

[17] Caterpillar Inc, *CAT tier 4 interim/stage IIIB technologies*, Peoria, 2010.

[18] Marine Exhaust Solutions Inc. (2007) *Marine Exhaust Solutions*. [Online]. www.marineexhaustsolutions.com/products_commercial.asp

[19] MAN Diesel, *Selective Catalytic Reduction*, Augsburg, 2010.

[20] Wärtsilä, *Wärtsilä $NO_x$ Reducer – SCR System*, Vaasa, 2011.

[21] Ecospec Marine Technology, *$CSNO_x$*, Singapore, 2012.

[22] MTU, *Selective Catalytic Reduction: Exhaust aftertreatment for reducing nitrogen oxide emissions*, Maybachplatz, 2011.

[23] MOD ((Undated)) Ministry of Defence. [Online]. www.mod.uk/DStan

[24] J. Miller and C. Bowman, *Mechanism and Modeling of Nitrogen Chemistry in Combustion*, Progress in Energy and Combustion Science, vol. 15, pp. 287-338, 1989.

[25] C. Ferguson and A. Kirkpatrick, *Internal Combustion Engines*, 2nd ed. New York: Wiley, 2001.

[26] Y. Cai, L. Lei, and P. Wang, *The Effect of Specific Input Energy on Promotion of NO–$NO_2$ of Diesel Engine with Non-Thermal Plasma Technology*, Advanced Materials Research, vol. 204-210, pp. 955-959, 2011.

[27] X. Tauzia, A. Maiboom, and S. Shah, *Experimental study of inlet manifold water injection on combustion and emissions of an automotive direct injection Diesel engine*, Energy, vol. 35, no. 9, 2010.

[28] D Agarwal, S Singh, and A Agarwal, *Effect of Exhaust Gas Recirculation (EGR) on performance, emissions, deposits and durability of a constant speed compression ignition engine*, Applied Energy, vol. 88, pp. 2900-2907, 2011.

[29] T. Johnson, *Diesel Emission Control in Review*, in Diesel Exhaust Emission Control, Detroit, 2008.

[30] J. Kusaka, Y. Daisho, R. Kihara, T. Saito, and S. Nakayama, *Combustion and Exhaust Gas Emissions Characteristics of a Diesel Engine Dual Engine Dual-Fueled with Natural Gas*, JSAE Review, vol. 21, no. 4, pp. 489-496, 2000.

[31] S. Panda, *Reduction of $NO_x$ Emission in Diesel Engines using Exhaust Gas Recirculation*, Rourkela, 2012.

[32] P. Forzatti, *Present status and perspectives in de-$NO_x$ SCR catalysis*, Applied Catalysis A: General, vol. 222, no. 1-2, pp. 221-236, 2001.


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[33] C. Sluder, J. Storey, S. Lewis, and L. Lewis, *Low Temperature Urea Decomposition and SCR Performance*, Detroit, 2004.
[34] B. Cho et al., *Selective catalytic reduction of $NO_x$ by diesel fuel: Plasma-assisted HC/SCR system*, Catalysis Today [Awaiting publication], 2012.
[35] K. Fujita, K. Nochi, Y. Wakatsuki, A. Miyanagi, and N. Hiraoka, *Development of Selective Catalytic Reduction for Low-Speed Marine Diesel Engines*, MHI Technical Review, vol. 47, no. 3, pp. 48-52, 2010.
[36] Dansk Teknologi, *Next Generation $NO_x$ Reduction*, Allerød, 2011.
[37] A. Mizuno, *Industrial applications of atmospheric non-thermal plasma in environmental remediation*, Plasma Physics and Controlled Fusion, vol. 49, no. 5A, pp. A1-A15, 2007.
[38] J. Jolibois, K. Takashima, and A. Mizuno, *Application of a non-thermal surface plasma discharge in wet condition for gas exhaust treatment: $NO_x$ removal*, Journal of Electrostatics, vol. 70, pp. 300-308, 2012.
[39] T. Yamamoto, M. Okubo, K. Hayakawa, and K. Kituara, *Towards ideal NOx control technology using a plasmaechemical hybrid process*, IEEE Transactions on Industrial Applications, vol. 37, pp. 1492-1498, 2001.
[40] T. Yamamoto, C. Yang, M. Beltran, and Z. Kravets, *Plasma-Assisted Chemical Process for $NO_x$ Control*, IEEE Transactions on Industry Applications, vol. 36, no. 3, pp. 923-927, 2000.
[41] V. Ravi, Y. Mok, B. Rajanikanth, and H. Kang, *Temperature effect on hydrocarbon-enhanced nitric oxide conversion using a dielectric barrier discharge reactor*, Fuel Processing Technology, vol. 81, pp. 187-199, 2003.
[42] H. Jun, H. Kim, Y. Sakaguchi, and Y. Hong, *Reduction of $NO_x$ and $SO_2$ in a non-thermal plasma reactor combined with catalyst and methanol*, Journal of Physics D: Applied Physics, vol. 41, pp. 205-213, 2008.
[43] B. Sawatmongkhon, *Modelling of Catalytic Aftertreatment of $NO_x$ Emissions Using Hydrocarbon as a Reductant*, Birmingham, 2012.
[44] S. Thagard, Y. Kinoshita, H. Ikeda, and K. Takashima, *$NO_3$ Reduction for $NO_x$ Removal Using Wet-Type Plasma Reactor*, IEEE Tranaction on Industry Applications, vol. 46, no. 6, pp. 2165-2171, 2010.
[45] J. Kaspar, P. Fornasiero, and N. Hickey, *Automotive catalytic converters: current status and some perspectives*, Catalysis Today, vol. 77, no. 4, pp. 419-449, 2003.
[46] A. Tarendash, *Chemistry, the physical setting*. New York: Barron, 2001.
[47] D. Perry and S. Phillips, *Handbook of inorganic compounds*. Boca Raton: CRC Press, 1995.
[48] C. DiMaggio, G. Fisher, K. Rahmoeller, and M. Sellnau, *Dual SCR Aftertreatment for Lean $NO_x$ Reduction*, Warrendale, 2009.
[49] T. Balon and N. Clark, *Development of a Combined Oxidation System and Seawater Scrubber to Reduce Diesel $NO_x$ Emissions from Marine Engines*, Manchester, 2011.
[50] L. Gill, P. Blakeman, M. Twigg, and A. Walker, *The use of $NO_x$ adsorber catalysts on diesel engines, Topics in Catalysis, vol. 28, no. 1-4, pp. 157-164, 2004.*
[51] A. Hinz, L. Andersson, J. Edvardsson, and P. Salomonsson, *The Application of a $NO_x$ Absorber Catalyst System on a Heavy-Duty Diesel Engine*, in SAE World Congress, Detroit, 2005.
[52] Tenneco, *Hydrocarbon Lean $NO_x$ Catalyst System*, Grass Lake, 2011.
[53] R. Goodenough, *Nuclear Aircraft Carrier*, London, 2007.
[54] Royal Navy. (2012) Royal Navy. [Online]. www.royalnavy.mod.uk/The-Fleet/Ships/Future-Ships/Queen-Elizabeth-Class
[55] J. Buckingham, N. McCallum, and I. Timbrell, *The Application of Gas Turbine Engines to Small Craft*, in World Maritime Technology Conference, London, 2006.
[56] G. Pahl, W. Beitz, J. Feldhusen, and K. Grote, *Engineering Design, a Systematic Approach*. London: Springer-Verlag, 2007.


# ROYAL NAVY OFFICER CADET EARNS TOP AWARD


22-year-old Officer Cadet Peter Whiteley's study into the fault detection in wind turbine gearboxes earned him the Babcock Award, the Science, Engineering and Technology (SET) Institute's prize for the Best Mechanical Engineering Student of the Year. The project formed part of his master's degree in his final year at Cambridge University and has also been nominated for the Naval Review Prize (the Naval Review is an independent journal, to promote debate within the RN, and offers prizes for the best papers and articles written by members of the Service).

Having been named on the shortlist of three finalists from over 500 entrants for the SET Institute prize, Peter was required to give a presentation and interview in London, which would determine the winner, but by this stage he had started his initial naval training at Britannia Royal Naval College in September 2012. Absence is not normally allowed during this period, however he was granted 24 hours special leave to attend.

Peter said: "*I'm really proud to be selected for this award. It was a great project to be involved in and hopefully the results will be of real use to the wind industry.*"

Wind power is the fastest-growing energy sector but high gearbox failure rates, initiated by bearing defects, are limiting the productivity of wind turbines, since replacing a gearbox costs in the region of £250000. Peter's work provided experimental proof that, using continuous vibration monitoring, the early detection of bearing failures in wind turbine gearboxes is possible. Once these defects are detected, maintenance could then be scheduled to prevent further damage to the gearbox and turbine assembly, potentially saving the operator millions of pounds.

Each year the SET awards recognise the best science and engineering undergraduates in Europe across 14 disciplines; each candidate is nominated by their lecturer or supervisor and provides a technical synopsis of a novel and innovative project they completed as part of their studies. This is submitted to a panel of judges from the SET institute, industrial sponsors and the relevant engineering institution who select a final shortlist.

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# FILTERING OUT THE LIGHT

## LASER EYE PROTECTION

A new type of laser eye protection (LEP) for pilots is being tested by the Ministry of Defence.

The Defence Science and Technology Laboratory (Dstl) has been working with Defence Equipment and Support (DE&S) to evaluate and assess the specially designed spectacles.

The LEPs can filter out different wavelengths of light from the spectrum, including those used in various laser weapons and laser pens, which are becoming increasingly available from the Internet.

*The prototype spectacles can filter out a range of different laser wavelengths, allowing greater operational benefits and flexibility for pilots (Picture: Crown Copyright/MOD 2012)*

Dr Craig Williamson, Principal Scientist at Dstl, explains the rationale behind the project work. "*There are an increasing number of incidents of inexpensive lasers being used to distract pilots, so we have been researching advanced technologies to mitigate this hazardous and potentially lethal distraction.*"

Unlike conventional LEP, which tends to filter out and block just one wavelength from the colour spectrum, the prototype spectacles, made by Glasgow-based company Thin Film Solutions, can filter out a range of different laser wavelengths, allowing greater operational benefits and flexibility for pilots. This is achieved by a composite structure comprising a polycarbonate layer made with a special absorbing optical dye, bonded to a thin glass lens with a special coating to reflect certain wavelengths.

The project work on the LEP is a good example of how funding from DE&S' Equipment Programme can be used to evaluate technology and assess it for potential benefits and uses, as Pete Douglass of DE&S explains: "*With funding from the equipment programme we were able to ask Dstl to evaluate this new LEP against older, more conventional filters in order to understand the development needs before they would be ready for service. In the case of the LEP, the research highlighted some clear strengths, whilst also showing some weaknesses of the technology which we are now addressing with future research.*"

The work has also benefited from an established partnership between Dstl and the United States Air Force, with testing taking place in May of this year.

Dr Williamson says: "*The bilateral work at the United States Air Force Tri-Service Research Laboratory in San Antonio proved to be invaluable. The results from this human performance testing (on spatial detection and colour perception) have set the benchmark for future work, and we're hoping that further bilateral funding will be available to research the next generation of eye protection in the coming years.*"

Further testing is to be conducted later this year, including optical performance and environmental testing by Dstl, and laser dazzle and performance testing at QinetiQ.

*A Tornado GR4 pilot signals to ground crew before deploying on a mission over Libya. The new eye protection is being developed to address the increasing number of incidents of lasers being used to distract pilots (Picture: Sergeant Pete Mobbs RAF, Crown Copyright/MOD 2011)*

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# A CLOSE SHAVE?

## By Paul Lloyd MBE FInstLM GCGI LCGI MCMI
## Electric Propulsion Systems

Paul, aka Jeff, joined the Electric Propulsion Systems team in March 2009 following 33 years in the RN, attaining the rank of WO1WEA(ADC). He joined the Navy as an Artificer Apprentice in 1975 at HMS Fisgard and was streamed as an REA. Sea training was undertaken in HMS Brighton before returning to Collingwood whereupon branch changes saw him complete the apprenticeship as a WEA (AD/CEW). Interspersed with SFM Devonport, where there was the opportunity to work on a broad range of WE equipment, two sea jobs as a section maintainer were undertaken in HMS Phoebe, Seacat radar and guidance, and HMS Charybdis, Seawolf surveillance radar. This was followed by loan service with the St Vincent and the Grenadines Coastguard with responsibility for anything electrical or electronic fitted to their four patrol boats. On return to the UK he undertook CCWEA QC and then at short notice joined HMS Coventry. Then it was back to SFM where time in the Seawolf Assistance Team was interrupted by a short foreign trip to serve with the United Nations Transitional Authority Cambodia. HMS Chatham followed and during this draft he was made an MBE. Advanced to WO1 where jobs as ASWEO F2, DCSA SO3 Customer Account Manager (Navy), FOST WESRI – foreign ships lead, MTE co-ordinator and finally back at SFM Devonport as FTSP Package Manager followed. He was awarded the Meritorious Service Medal in 2007 just prior to leaving the RN in March 2008.

**INTRODUCTION**

In mid 2009 HMS Argyll reported damage to one of her propulsion motor commutators. This was caused by brushes wearing down beyond their minimum limit, resulting in the copper tails scoring the commutator segments. Both commutators were profiled by ESG staff to establish the shape and truth of running and the results showed that both were in a similar condition. A PUMA was conducted in HMS Lancaster and likewise the commutators were noticed to be visibly damaged. At this point it was decided that all of the Type 23 commutators should be profiled and the remaining commutators were subsequently checked over a 12-month period and all displayed varying levels of degradation.

**THE PROBLEM**

The rough surface, seen in Figure 1, causes increased brush wear that consequently leads to an increased production of carbon dust. This conductive dust has subsequently coated many components within the motor; static field windings and rotating armature windings, busbars, brush gear, insulators and motor internal casing. There has been a commensurate reduction of the motor's insulation resistance (IR) and this could subsequently lead to a flashover (now more commonly referred to as "Arc Flash") event within a motor. The lowest acceptable limit of IR in the motors is 1 Mohm. Low IRs were reported in several vessels and the lowest was an armature at 0.45 Mohm, reported by HMS Kent. She was emerging from upkeep and was initially directed to clean the brushgear and retake measurements. The IR increased marginally and, following a system split by disconnecting the motor's busbar link plates, the low IR was determined to be within the motor's armature windings/ commutator risers. Ship's Staff were subsequently directed to obtain specialist assistance to carry out a deep clean of the motor, to avoid the possibility of a flashover – Figure 2[1].

The main concern with a flashover is whether or not personnel could be injured by the event. A flashover was increasingly likely to occur if no action was taken to improve the condition of commutators and reduce the dust levels within the motors. Following two safety reviews, it was considered that the most likely area that a flashover would occur would be within the brushgear and that this may or may

1. http://www.wmea.net/Technical%20Papers/Technical%20Developments%20in%20the%20Measurement%20of%20Commutator%20Profiles%20-%20Nov%2007.pdf, (accessed 18 December 2012).

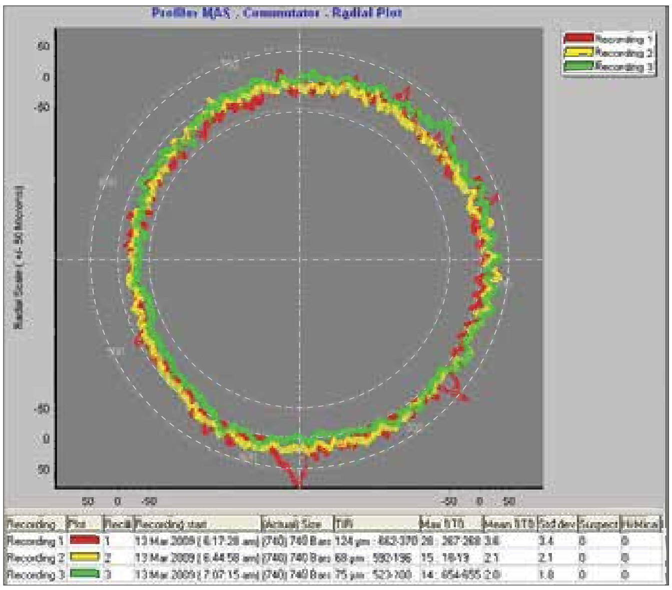


*Figure 1: HMS Argyll profile before repair*

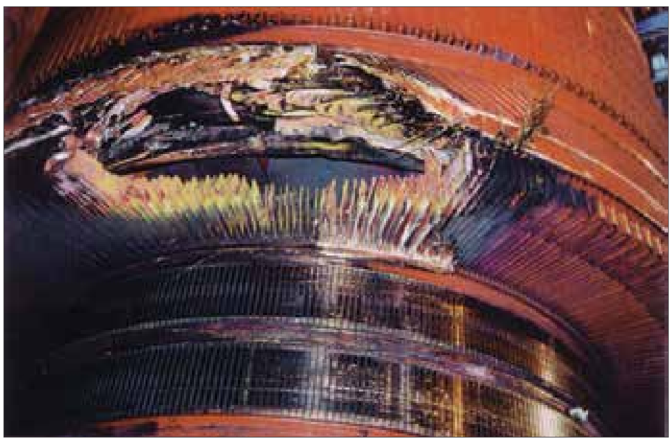

*Figure 2: This is what we're trying to avoid*

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not involve the actual commutator surface. It was determined that if this happened, as long as all covers are correctly fitted, there is no inherent risk to personnel as the design of the motor, in conjunction with the protection circuits within the converters, should immediately cause the main Air Circuit Breaker to trip and any flashover would be of relatively minor size. A flashover in this area should be materially recoverable in a short space of time, certainly within a month if STOROB is undertaken, but within six months otherwise.

A flashover within the static field windings and armature windings or commutator risers, however, could be more catastrophic and would entail much longer, more costly, repair activity. There are no spares, and manufacture of a new armature would take a considerable time at high cost. There is no shipping route and extensive work in way would be required to enable a removal and replacement to be conducted. Subsequent alignment of the armature within the motor would be very time consuming as new datums would need to be established. In this event a ship could potentially be out of operation for up to 18 months, with costs estimated at 3.5 to 4 million pounds.

**INVESTIGATION**

In the course of carrying out the commutator profile checks, it was suspected that maintenance was not being carried out correctly as the commutators and their associated housings were very dirty with considerable amounts of carbon dust deposited throughout. The commutator air outlet filters were generally dirty, thus reducing air flow, which therefore meant that the only air path would be through the commutator risers and motor windings and finally out via the heat exchanger. There are two different commutator outlet air filters and, in several instances, the wrong combination was fitted. Tallies have subsequently been supplied to ships showing the correct NSNs and orientation of the filters within their housings.
It has also been found that heat exchangers have not been cleaned externally for several years and this, combined with water connections being the wrong way around, is undoubtedly contributing to high motor temperatures, which in turn increases the MGR temperature. Although the maintenance task has already been rewritten, this will be the subject of another task aimed at completion during refits.

The main cause of the damage was initially thought to be poor brush maintenance but whilst this is a major factor, which has resulted in brush tails (the copper connecting wires) scoring the commutator surface, further causes were suspected as being contributory and complicating factors. Indeed, it was clear that some commutators exhibited no signs of brush tail scoring, but nonetheless returned poor profile results.

Repairs were originally being achieved by skimming the commutator surface to remove the damage, restoring the surface to an almost 'as new' condition. At two weeks per shaft, this is time consuming and very expensive, and requires the affected shaft to be turned using the gas turbine, thus utilising valuable GT running hours and requiring additional maintenance on them. As the shaft is turned at low speed, this means that the GT was being run for prolonged periods at idle, which had the potential to cause damage to the combustion cans.
It also requires the use of several members of the Ship's Company and dockyard support for the periods that the ship is in basin trial conditions.

**EMERGENT WORK AND IDEAS**

The early realisation that we were treating the symptoms and not the potential causes resulted in further work being identified as necessary; changing brush holders to ensure spring pressures were restored to their design level, checking the neutral axis, brush arm spacing, voltage drop tests and equaliser checks. This was initially carried out as a separate package of work, but is now incorporated as part of the commutator repair.

By further analysing the profile results, it was thought that many of the commutators could be restored to a satisfactory condition without skimming and this was confirmed by obtaining independent expert advice, which established that they could be

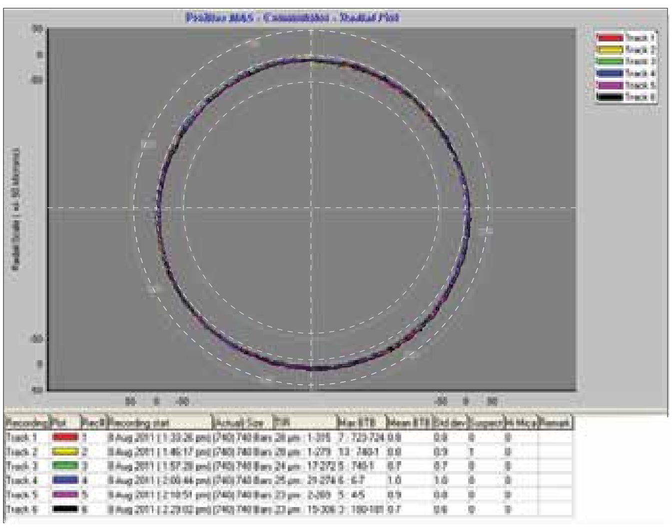

*Figure 3: HMS Argyll following repair by skimming*

*Figure 4: Damaged Neutral Axis Pin in HMS Iron Duke. If something isn't moving, check that everything is in the correct condition – a bigger hammer isn't always the right answer! New redesigned pins are being fitted as part of the commutator repair task.*

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Figure 5: Checking the condition of the brush as well as its length.


Figure 6: Compromised insulator creepage distance – these insulators should be white

repaired through the use of grinding stones. This method is achieved at lower cost, in less time (eight days) and does not require the use of the GT to rotate the shaft. It does not restore the commutator to a perfect circle, but does restore it within limits. Additionally, in most circumstances, both shafts can be repaired concurrently thus saving almost three weeks of ship's programme.

Some of the damage is clearly as a result of the brush tail scoring and note that it is not just the length of the brush that is important, it is also its condition. Charts to aid ship's staff in recognising different brush and commutator conditions have been passed by the EA to all ships. Brushes should be changed when they reach a length of 20mm or if damaged. At 16mm the tails will be exposed to the commutator face and will begin gouging the surface. It only requires one brush to be missed when carrying out the inspection to cause damage. No records had been kept previously that demonstrated any wear rate trends, therefore a brush may be over 20mm when inspected, but could be below the 16mm point at the next six-monthly inspection. Wear rates are dependant on several factors including operational use (speed and distance), environment, commutator condition, spring pressures and cleanliness.

Cleanliness can have a significant impact as the dust generated by brush wear can be abrasive, therefore having a cumulative erosion effect. The dust can clog the brush holders leading to brushes sticking and causing underbrush sparking damage to the patina of the commutator surface, wearing brushes quicker and damaging the commutator profile. It coats the busbars and cables, contributing to reduced IR and reduced creepage distance on the insulators within the commutator housing – Figure 6. The dust has been found to clog the brush gear rocker ring roller bearings, making it very difficult to rotate the brushgear to gain access to inspect and clean the lower brush gear. This has been a contributory factor to lower brush sets not being checked correctly.

The brush wear records received showed varying amounts of brush wear for brushes travelling over the same part of the commutator. This could possibly have been due to sticking brushes or spring pressures. It was determined that the brush spring pressures could not be accurately measured, due to the construction of the gear. On sending a sample of holders to the OEM for bench testing, it was found that all were significantly under pressure. This leads to vibration and poor surface contact leading to underbrush sparking. This is exacerbated by the poor commutator surfaces. There is little point replacing random brush holders as unequal brush spring pressures leads to uneven current distribution across a set of brushes – Figure 7[2]. It was decided that the holders would be changed as part of the repair and thereafter, subject to the results of trials of new style brush holders, they will be changed during upkeep periods, either for the new variant or for another replacement set of the current variant.

Records of IR checks had also not been kept and this meant that no trend analysis could be made with respect to brush wear/ dust generation. The UMMS task instruction lacked detail: "Open relevant terminal box and measure IR", and, when questioned, ships' staffs had not been clear on where or how to conduct these tests.

2. http://www.wmea.net/Technical%20 Papers/NECP%20&%20Foundation%20 Coal--Benefits%20of%20Knowing%20 Your%20Commutator%20Profile.pdf, (accessed 18 December 2012).

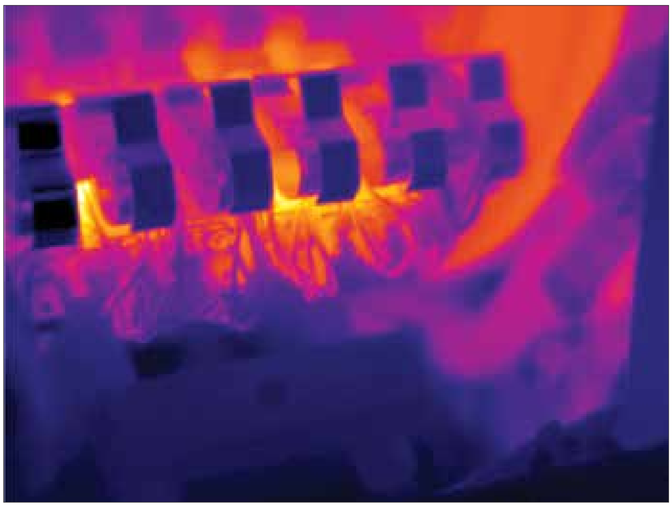
Figure 7: Uneven current collection due to uneven spring pressures

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There isn't a motor for training purposes in Sultan, so the first time a maintainer sees the equipment is when they join the ship. Add to this the complications caused by gapped billets (no handover) and no in-depth knowledge within a ship (everyone previously having served in Type 22s, Type 42s, CVS etc), and it's easy to see how the situation may have arisen. However no S2022s or S3018s were raised to highlight the issues.

There was an annual task to inspect the condition of the wiring and connections within the terminal boxes, where the IR readings would be measured, but this task was no longer undertaken due to it being deemed unnecessary in an RCM study. There have been incidents of loose field connections leading to terminal and cable damage in at least three ships – Figure 8. Checking that terminals are tightened correctly may have been removed from the maintenance schedule as such conditions can be located by thermographic surveys. However, it would appear that these surveys are not always finding the problems. When are the surveys being conducted and are these boxes even included? If alongside, the motors won't be in use and therefore no heat will be generated in the terminal box. The requirement to clean, inspect and check connection security in these terminal boxes has been addressed in the IR task rewrite.

How has the Type 23 ship life extension plan affected other equipment studies and assumptions? The assumptions made in RCM studies need to be checked and the impact of changes to other procedures needs to be understood clearly by all interested parties.

As the propulsion motors have no bearings of their own, any wear/changes made in the gearbox and the shaft line will affect the position of the armature within the propulsion motor. This will have an effect on the motor's electromagnetic balance which in turn will lead to poor motor performance – current imbalances, for example, leading to increased heat generation and

*Figure 8: Damaged connections and cables in a Field Terminal Box in HMS Somerset – luckily, repaired without needing to run a new cable.*

vibration – which could affect the ship's radiated noise signature, as will the poor commutator surface. The clearance for setting up motor components on the shaft is small. The poles are checked and set during manufacture to ensure that the clearances are within 5% of each other across opposing poles. Datum measurements are established at three points at the FWD and AFT ends of the Motor and these are stamped onto the motor adjacent to the Concentricity Measuring points. There was a 6M task to check the armature concentricity, but this was no longer being undertaken. It has now been reinstated. The correct armature alignment will need to be confirmed prior to any commutator repair (skim or stone) being conducted.

## CONCLUSION

A lot has been learnt and much has been done in an effort to arrest the decline of these important assets. The repair method has developed to give appropriate options, look for the causes and ensure they are eliminated, review maintenance and introduce records to aid decision making.

The commutator repair work package includes:

- Pre-repair profile check to ensure that there are no alignment issues and to confirm the repair method – skim or stone.
- Commutator surface repair, either stoning or skimming dependant on severity of damage. Undercutting micas and bevelling as required.
- Fitting of a new Neutral Axis Pin.
- Neutral Axis Check.
- Brush Arm Spacing Check.
- Voltage Drop Test.
- Equaliser Winding Check.
- Insulation repairs.
- Insulation Resistance Tests.
- Replace brush holders.
- Replace and bed in brushes.
- Replace brushgear roller bearings.
- Reset brushgear locking clamps.
- Reset shaft earth brush holders.
- Post repair profile.

UMMS tasks have been reviewed and where necessary, the JICs have been amended or new ones introduced. Drawings and tallies have been developed and included to aid with the identification of locations and settings. Charts have been supplied to enable the condition of commutators and brushes to be determined.

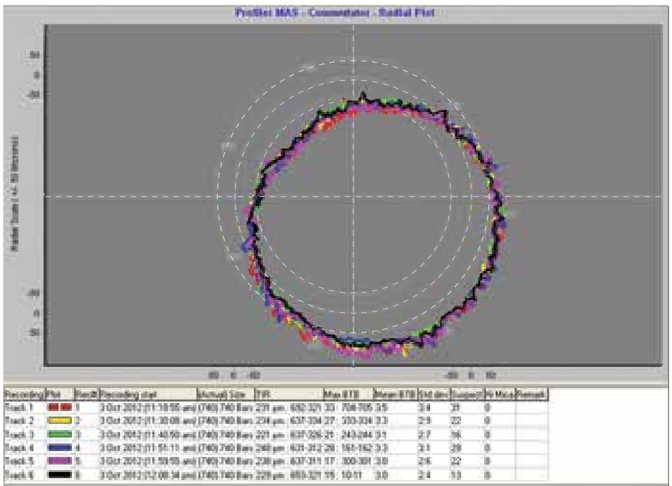

*Figure 9: A profile indicating misalignment in HMS Portland*

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A Microsoft Excel-based motor record has been created and is in use in all ships. Hard copy should be kept in the SEF and an electronic copy should be forwarded to ESG each time maintenance is conducted. Ultimately, the aim is to host all records in MOSS and ships should be able to access and update them accordingly using DII.

Trials of a different type of brush holder and brush are underway in HMS Lancaster and HMS Northumberland.

We will never really know how close we were to having a major flashover in one of our motors, however if the situation had continued major damage within one or more was inevitable and would have resulted in the loss of the affected ship(s) for a considerable time. The RCM study and introduction of UMMS removed maintenance tasks and the ship life extension of the class has undoubtedly compromised the results of the study. A proactive approach, in questioning how many motors may be damaged, conducting tests and centralising the records, revealed that there was more than one cause. A safety review led to engagement with industry experts who have subsequently worked closely with the EIPT and COM teams to repair the commutators and to investigate and eliminate causes.

The task is not finished:

- By the summer of 2013, all but two ships will have had their commutator repair packages completed.
- Further modifications to the brushgear are being reviewed.
- To safeguard the motors' IP rating, work has been initiated to include the replacement of fastenings on the commutator inspection panels and, if necessary, replace shaft seals in future work packages.
- Training will be reviewed in 2013, in conjunction with modifications planned for the converters, and the safety case will be reviewed yet again.

### GLOSSARY OF TERMS

| | |
|---|---|
| COM | Class Output Management |
| EA | Equipment Authority |
| EIPT | Equipment Integrated Project Team |
| ESG | Electrical Systems Group |
| IR | Insulation Resistance |
| JIC | Job Information Card |
| MGR | Motor Gear Room |
| NSN | NATO Stock Number |
| OEM | Original Equipment Manufacturer |
| PUMA | Pre-Upkeep Material Assessment |
| RCM | Reliability Centred Maintenance |
| UMMS | Unit Maintenance Management System |

# JUNGLIES RECEIVE ROLLS-ROYCE ENGINEERING EFFICIENCY AWARD

The Engineers of 845 and 846 Naval Air Squadrons have been jointly awarded the 2012 Rolls-Royce Engineering Efficiency Award for their outstanding performance in Afghanistan in the period April 2011 to March 2012. This award is presented annually to the Fleet Air Arm squadron, flight or Fleet unit judged to have achieved the best overall standards of engineering efficiency and effectiveness.

Against strong competition within a heavily tasked Air Arm, the Squadrons were jointly recognised for their support to the Operational Mentoring and Liaison Team Afghanistan (OMLT(A)). This enduring commitment, based at Kandahar Airfield in Afghanistan, has been ongoing since 2007, with Flights and aircraft from both Squadrons in rotation.

The lean manned detachment of only 23 engineers has delivered aviation operations continuously at high levels of readiness and aircraft availability despite extreme temperatures and difficult working conditions. Maintenance has had to be carefully managed in order to meet the high readiness posture and frequent requirement for 100% availability. In achieving this demanding target the engineers have repeatedly shown their resourcefulness, resilience and leadership.

*Engineers prepare a Sea King 4 for a mission over Afghanistan*

To underpin the success of the Engineering team, CPO Barry McGeough, the SMR of D Flight, 846 Squadron, added, "*Our engineers have managed to deliver 100% of the required operational flying hours. In one particular month, the detachment flew 20% more flying hours than mandated, underpinned by an incredible serviceability rate of 87%. In addition to the challenges of the environment, climate and austere infrastructure, there have also been major technical challenges to overcome. Over the past 12 months the detachment has coped with 11 Engine, three Main Rotor Gearbox and two Main Rotor Head changes. This significant achievement clearly demonstrates how highly motivated and utterly focussed our engineering team is.*"

The award was presented on 14 December 2012 by Commodore Simon Baldwin RN (Rtd), Rolls-Royce Director of Programmes, and received by the Air Engineer Officers of 845 and 846 Squadrons (Lieutenant Commanders Nick Sargent and Brian Nicholson).

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# HOW DO WE GROW ENGINEER OFFICERS?

We expect a lot from junior engineers joining the officer corps. This article, drawn largely from the relevant sections of the DTOEES Annual Report 2012, describes the military involvement in their undergraduate education.

## INTRODUCTION

The maintenance of an intellectual edge and technical expertise is instrumental to battlespace success and is fully supported at the strategic level, highlighted in the National Security Through Technology White Paper published in February 2012:

"*We need to exploit technology advances more rapidly into our capability, but we also need to recognise that science & technology is fundamentally based on specialist skills and experience, which take time to develop – in some cases these take a decade to become effective. Therefore, it is vital to sustain long-term investment in science, technology, engineering, and mathematical skills to support our specialists in industry, academia and within Government*".

## DTOEES BACKGROUND

The Defence Technical Officer and Engineer Entry Scheme (DTOEES) was established in 2005 in response to the 2001 Defence Training Review, which concluded that Defence had historically and consistently failed to provide enough technical officers and engineers of sufficiently high calibre to meet requirements. DTOEES augmented the provision of sixth form scholarships and replaced in-house undergraduate degree training (eg RNEC Manadon) through the establishment of the Welbeck Defence Sixth Form College (DSFC), a non-fee paying boarding school specialising in a science-based A-level curriculum operated through a PFI contract, and partnership agreements with six universities offering accredited engineering degrees relevant to the Services under the guise of the Defence Technical Undergraduate Scheme (DTUS).

DTOEES delivers training at DSFC and four DTUS Squadrons to the following groups of trainees:

- **DSFC Students** – these are military/DESG sponsored engineering students studying A-levels at DSFC.

- **DTUS Bursars** – these are ex-DSFC sponsored students or Direct Entrant sponsored engineering students studying for an undergraduate degree or masters degree.

- **In-Service Degree Officers** (ISDOs) – following Initial Officer Training (IOT), a small number of Army officers will study at a DTUS University for a degree on the approved courses list as agreed with their parent Service or Corps.

- **RN Upper Yardmen (Engineer)** (UY(E)) – Thunderer Squadron parents ratings studying for engineering degrees at Portsmouth University prior to the UY(E) conducting Initial Naval Training (Officer)) at BRNC Dartmouth.

The main focus of the scheme is academic study to ensure all participants gain technical degrees in subjects approved by the Services.

In addition to their studies, all DSFC and DTUS students engage in a programme of military skills training. This programme focuses on the following areas:

- Service awareness and application of military engineering.
- Leadership training.
- Adventurous and robustness training.

**DTOEES HEADQUARTERS**. HQ DTOEES is located at the Defence Academy, Shrivenham, within the College of Management and Technology. It supports the Welbeck DSFC and the four DTUS Squadrons for HQ functions whilst also carrying out the contract monitoring of the Welbeck DSFC PFI Contract.

**DSFC WELBECK**. DSFC Welbeck opened in September 2005 and is operated under a 28-year PFI contract with Minerva Education and Training Limited. The College offers a science-based curriculum to students pre-selected for the Armed Services IOT or the Civil Service DESG/Graduate Entry Scheme (GES), leading to the study of accredited engineering and technical courses at undergraduate and master's level at the DTUS partner and associated Universities. In addition to the MOD sponsored students, the PFI allows up to 10% of Welbeck private students to attend DSFC.

**DTUS**. The four DTUS Squadrons exist to provide academic mentoring, guidance, personal development and military skills training for DTOEES bursars, ISDOs and UY(E) and are located as follows:

- **Taurus Squadron** (Birmingham) – partnered with Birmingham and Aston Universities, and also supports DTUS Bursars at Oxford University.

- **Thunderer Squadron** (Southampton) – partnered with The University of Southampton, and affiliated to Solent University for a limited number

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of students. The Squadron also supports DTUS Bursars at Imperial College, London and RN Upper Yardmen studying at Portsmouth University.

- **Trojan Squadron** (Newcastle) – partnered with Newcastle and Northumbria Universities.

- **Typhoon Squadron** (Loughborough) – partnered with Loughborough University, and also supports DTUS Bursars at Cambridge University.

Last year's trial introduction of a foundation year at Northumbria University saw nine of the ten students progress onto their first year of proper undergraduate studies and take up a DTUS bursary. This year a total of 22 high-quality students, who would have otherwise been withdrawn from the Scheme, are undertaking foundation years at either Aston or Northumbria Universities. This new initiative enables those DTOEES students with good officer potential, but who may have entered Welbeck at a lower academic level, to remain in the Scheme. No bursary payment is paid during the foundation year. The effectiveness of this will be monitored by Squadron COs against their university exam results.

**PAN-DTUS TRAINING**

A series of exercises involving all the DTUS Squadrons takes place every year. This year, this included:

- Adventurous training, where bursars can either attain a basic adventurous training (AT) qualification or progress through more advanced stages in their discipline, choosing between hill-walking, caving, climbing, kayaking, dinghy sailing, offshore sailing and mountain biking. The majority of instructors are third or fourth year Bursars who were introduced to the activity in their first year, demonstrating the progression that can be made whilst on the Scheme, which will bring many personal development benefits to their future sailors, soldiers and airmen.

*2nd Year military field exercise*

- An exercise for all second year students in field conditions on the Catterick Training Area for a week in order to develop leadership, robustness and team spirit. The exercise was based around a disaster relief scenario, with each DTUS Squadron running day-long programmes of practical leadership tasks, culminating with a training serial in the Operations in Built Up Areas village and an endurance event on the final day.

- A final year exercise in order to prepare the bursars for IOT, developing bursars' leadership and teamwork through a series of military command tasks conducted under conditions of physical and mental stress. This year's exercise saw nearly 200 personnel deployed on the Exercise including an invited group of US Air Force cadets.

- The annual DTUS FIT CAMP was run in parallel with the AT exercise, providing a week of fitness training and healthy lifestyle lessons for DTUS bursars, irrespective of year of study, who have not been able to pass their Personal Fitness Test.

- Sixty bursars drawn from all four Squadrons deployed to Neustift, Austria during Easter leave to develop leadership, trust, moral courage as well as improve their Alpine and ski-touring proficiency. All the instructors for the Exercise were serving soldiers, allowing the bursars to understand the calibre of the people they will serve alongside and, one day, command.

**DTUS SQUADRONS**

Situated across the country, the DTUS Squadrons inevitably have their own approaches to meet their aims and requirements; Thunderer Squadron's activities in the past twelve months serves as an example.

Led by Commander Chris Ling, Thunderer Squadron is currently collocated with the regional University Royal Naval Unit in Capella House, a privately rented building in the centre of Southampton. However, it is likely that Thunderer and the URNU will move into the National Oceanography Centre, a University of Southampton Campus site, in June 2013.

As the RN lead unit in DTUS, Thunderer has recently taken command of the Upper Yardman (Engineers) at the University of

*The National Oceanography Centre*

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Portsmouth. Upper Yardman (Engineers) are naval non-commissioned officers who have been selected for Officer Training at BRNC, but are required to top-up their in-service foundation degree to a full bachelor's degree through a final year at the University of Portsmouth. Their experience in the Naval Service is expected to pay dividends in growing the Service ethos amongst RN Bursars and developing a broader military understanding across the Squadron.

**Military Training**

All bursars enjoyed a broad range of military activity over the year, ranging from in-house training to unit attachments and corps competitions. Particular highlights included Exercise Thor Challenge 12, a challenging field exercise on Dartmoor which tested over 100 bursars' ability to approach engineering and physical tasks while fatigued. A favourite task required the construction of medieval siege engines such as slingshots and trebuchets.

**Adventurous Training**

The Squadron's emphasis on AT has been maintained this year, with an increased number of 48-Hour-Rule AT weekends being led by bursars. Over the year there have been regular expeditions covering yachting, dinghy sailing, rock climbing, freefall parachuting and caving. With a growing cadre of instructors led by Officer Cadet Lawrence Myatt, the Thunderer Caving Club has been recognised as the most active caving organisation in the MOD. This has been enabled by the recent purchase of more advanced equipment and donations of equipment by the Combined Services Caving Association. Once again the Squadron submitted a team to the Three Peaks Yacht Race – in which the members sail between Snowdon, Scafell Pike and Ben Nevis and run up each peak, and the team won the Light Infantry Bugle Trophy, finishing sixth overall.

**Squadron Events**

Thunderers have attended a variety of attachment and exchange programmes this year, including the US Naval Academy Annapolis, the Joint Force Command Naples and the US Air Force Academy Colorado Springs. These events have allowed students an early insight into the benefits (and challenges!) commonly encountered when working closely with other nations' armed forces on operations. In the return leg of the exchange partnership with France's École Navale, two French Midshipmen completed a semester of study at The University of Southampton and fully integrated themselves into Squadron life. Thunderer has also maintained its links with the local community, helping in civic charity projects and marching with other Hampshire military units in the Southampton Remembrance Day parade. Ties with 17 Port and Maritime Regiment, a local Royal Logistic Corps unit, have flourished, exchanging AT Experience and expertise for military instructors and equipment. The squadron is looking forward to the opportunities offered by a new affiliation with HMS Artful, an Astute-class submarine currently in build at Barrow-in-Furness, and renewal of an affiliation with HMS Illustrious. The Squadron has been an enthusiastic, and usually successful, participant in intra-mural sports both in university and military competitions and leagues.

*Building a siege engine*

*Freefall parachuting*

*Underground engineers*

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**WHAT DO THEY DO, WHEN NOT HARD AT WORK WITH ACADEMIC STUDY?**

So what do our future engineers get up to on these activities? Your editor was offered a number of reports from RN students on exercises, visits and expeditions, ranging from endurance tests through mountaineering and rock-climbing in Italy, navigation training at Annapolis US Naval Academy and attachment to NATO HQs in Italy to an educational visit to Beijing and Wuhan, in China. From this varied selection, some samples will give the reader an impression of the range of things which go on.

## Trojan Squadron

Midshipman Bateson, of 4 Troop, Trojan Squadron, took part in the first event of the CO's Shield competition, conducted to challenge physical fitness, mental strength and robustness.

This comprised several "tasks"; the first which was the bergen run, designed to simulate the movement of artillery shells from an ammo dump to a Gun Line. In groups of four, two move the bergen to the top of the hill, the other pair returned the 'expended 40kg shell.' This was repeated until all members of the troop had been up and down the hill. The next task was easily the most fun; all members of the troop had to be transferred from one side of 'land-mined' area to another, using rope to pull each other across.

Fatigue kicked in as they set out for task three, and they decided to force march on the uphill stretches of the route and jog the flat and downhill parts to conserve energy. At the bottom of a big muddy hill there was a log waiting which was picked up and carried back to the top and then back and after dropping the log they pushed onto the fourth task, carrying two jerrycans.

This was the longest and hardest route of the day, as it was mainly uphill. On arrival, there was 20m of mine tape to crawl under. The whole troop had to leopard crawl there and back before we could begin our journey back again, with full jerrycans.

They then set of for the fifth and final task, for which they were given helmets and put in a mine tape prison from which all had to escape using two planks of wood. After helping each other climb up and over the mine tape to escape, they were given a metal bar to carry and off back to base.

The final race was now upon them, tasked to move all their equipment (an artificial gun) to a gun line and return. The Troop finally arrived within minutes of the winners, with a respectable time of 1 hour 52 minutes in 4th place.

*Bergen Retrieval*

## Exercise Shrivenham Dolomia

### Introduction

Thunderer Squadron ran a 14 day rock climbing and via ferrata[1] expedition in August 2012, mostly in the Dolomites, Northern Italy, with a short period bouldering in Fontainebleau, France. Twelve participating personnel were Officer Cadets from Thunderer Squadron, a further three Officer Cadets were from Typhoon Squadron as well as one instructor from Southampton University Air Squadron. The climbing in the Dolomites was at a level far above anything in the UK with a huge variety of single, multi-pitch and via ferrata routes over a wide range of grades. All group members were surprised how quickly the days passed and felt 10 days in the Dolomites was not enough to truly get the most of the region.

Overall the trip was a great success with everyone pushing their climbing, with all novices having led at least two sport routes, a long mountain multipitch route and one via ferrata by the end. The exposure to a mountainous region so different to that of UK terrain allowed both instructors and students to further develop their adventurous training experience ready for further qualifications.

The climate in Northern Italy meant no wasted days due to poor weather during the expedition. It is very unlikely this could be completed in the UK. The addition of the via ferrata into a rock climbing expedition was enjoyed by all who partook. This type of alpine mountaineering is not possible in the UK environment and the via ferrata in the Dolomites provides an insight into mountainous warfare during the world wars.

### Two Extracts from Officer Cadet Perry's report:

"Myself, Mid Thomas, Mid Leveridge and OCdt Heath all headed to a north-facing crag to attempt our first multipitch. It was on a 6A route[2], which we didn't realise until we descended and met some others who had arrived with a guide book.

1. Protected climbing routes based upon a steel cable which runs along the route periodically fixed to the rock. The climber can secure himself or herself to the cable which can also be used as aid to climbing; climbing aids, such as iron rungs, pegs, carved steps and even ladders and bridges are often provided. Via ferrata allow otherwise dangerous routes to be undertaken without the risks associated with unprotected scrambling and climbing.

2. For those (such as your editor!) unfamiliar with the climbing terms used here, explanations can easily be found on the Internet – these are not, however, essential to an understanding of the events.

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Leveridge realised as we were climbing that the route was particularly difficult, and whilst I was struggling on a particularly difficult traversing section "*If you can do this you can do anything*". It was a difficult climb that took around an hour for both of us to complete, with a nice abseil down."

Later … "Multipitching with Mid. Gillman was the day I felt I had achieved the most. The day started with quite an easy three-pitch climb which was only a 4B. However some problems did arise after both of us had made our descent by abseil, the ropes had become jammed in the rockface way out of our reach. Luckily some of the climbers who were already going up the route understood "*CAN – YOU – HELP – US*", and what exactly needed doing.

Then, on the second climb of the day, we went up Cinque Torri, which was a 10 pitch climb that was roughly a 5A, with some parts that were 5B. The climb was good, however at one point on the ascent, Rob managed to get the rope stuck as it was going round a tight corner prior to a traverse. "*I can't go up, I can't go down, I can't go anywhere!*" This was much to the amusement to OCdt Gill and Leveridge who were watching from below having already completed the route. The issue was resolved in 10 minutes, and we were soon climbing again.

On the descent, after being swarmed by flying ants at the summit, we abseiled down, as the guidebook said, roughly 15 metres to a ledge with a single piton. When I arrived after Rob, I said "*Are you sure that's safe*", pointing at it. The piton moved! Unfortunately due to only climbing with one 60m rope it was a bit late for this observation and the abseil rope had already been pulled down. This was the second mini-epic of the climb. To resolve the problem, I down-climbed first being lowered by Mid Gillman from an improvised anchor of the dodgy piton and two cams, to a ledge 6m below. Luckily the ledge had good 'bomber' anchors that could safely be abseiled from. However Rob was still above me, and would need to down-lead. With a stroke of genius, after removing his cams and remaining gear from the top, he down-led using a 2m sling and hung it over anything he was level with, before descending on it and then whipping it off."

*Mid Gillman attempting the F7a+*

**USNA Attachment,**
**by Midshipman Dean**

Five DTUS Midshipmen visited the US Naval Academy, Annapolis, Maryland. The aim of this exercise was to participate in a US Navy training programme designed to teach basic sea navigation skills on yard patrol vessels to midshipmen in training.

After introductory briefings, the first afternoon consisted of our first practice experience of plotting on a chart. The following day, after work in the classroom to practice chart work and navigation and getting to know the crew we would be sailing with, in the afternoon we prepared our charts for the next day's route and finished off our timed exercise, followed by a Rule of the Road test which was intriguing as our experience with Rules of the Road was the quick twenty minute lecture we had been given the day before, so it was quite amusing when in our group, the internationals had a higher average than their US second class Midshipman.

Next day was the first day out in the patrol boats, which included the first experiences working as a watch team! Discovering that some of the jobs were much harder than first thought, working as plotter I was struggling to keep up with the plots but by the end of the first watch I was finally getting the hang of how the American bridge was working.

The afternoon was spent in the classroom revising for the proficiency test due to take place the following day. This involved practising the rules of the road, and adjusting our course to take into account tides.

The group then had a long awaited weekend of 'liberty'. For us DTUS students, this took shape in the form of a trip to Washington DC.

After an exhausting day in Washington, it was another early morning ready to get ready for passing the certification test. With the morning spent underway on the YP's the majority of us were given

*All at sea*

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the afternoon off to do with what we wish.

The day started with practice Nav Briefs before the Captain of Navigation Training came on board to assess the boat for its out of area certification. The Captain assessed the crew from the bridge, and asked a range of questions to everyone. Our boat was marked not effective and did not pass the certificate due to multiple factors, such as turning the watch over during a manoeuvre, and coming far too close to a buoy, the reassessment was scheduled for three days time.

On the final day of preparation before our 24 hours underway, the morning consisted of a food onload, with about a kilogram of turkey meat for each person; I became unsure as to what I had got myself into, and there was no way each person could eat that much turkey. With the final food upload done by 0930, we were all a bit confused as to what was meant to be happening with the rest of the day and half hoping we could get some time off to chill out. To out dismay we discovered there was a Nav brief later that day which went on far too long for a Nav brief so finally we were ready for our 24 hour deployment! A successful deployment into Chesapeake Bay concluded the training element of the exercise; the remainder of the exercise involved cultural visits to various areas on the East Coast of the USA[1].

1. A small point, but worth remembering when working with the NATO's largest navy – on the trip it became evident that the national curriculum seems to ignore any of our history associated with America. To this end it is beneficial to read up on at least the Naval History such as the War of 1812.

**Midshipman Steele, from Taurus Squadron, reports on a trip to China.**

The trip aimed to integrate future students from the UK and China prior to starting the university term.

The School of Electronic, Electrical and Computer Engineering at the University of Birmingham has links with some Chinese universities. Students from these universities are given the opportunity to complete some of their study at Birmingham. In order to help those joining the second year course to integrate with the UK students, the school sends about ten students each year for a two week programme of experiencing the country and doing some work with the prospective attendees of the second year course. We spent the first week in Beijing, accommodated at Beijing Jiaotong University, which is exclusively for transport-based research and education. The focus there was to adapt to living in China and get a feel for what it is about. We consciously avoided anything westernised and spent the evenings eating some interesting food, then exploring shops and bars in order to practice a very limited repertoire of Mandarin phrases and absorb some culture.

We then caught an overnight train to Wuhan, a sprawling industrial city seven hundred miles south of Beijing. Here we were hosted by Huazhong University of Science and Technology and split our time between a project run by Birmingham lecturers and classes in Chinese culture and language. The task was to produce a vehicle that could autonomously navigate a course of obstacles on a flat floor. The Chinese rarely have the chance for open design so this was very different for them and it took suggestions from the British students to push them in the right direction. Their diligence and interest however was clear.

The afternoon classes included language and culture to deepen appreciation of Chinese life and ease getting to know the students. Basic phrases and concepts of the language were taught and we were given introductions to Kung Fu, paper cutting and production of Chinese dumplings.

Hopefully we fulfilled our role of building a rapport with the Chinese students and experiencing some culture. Part two will come in September when we help the Chinese to adapt to a very new way of studying and a very different place to live.

*The School group in China*

**A report on Exercise NATO Surprise**

**Introduction**

Five Midshipmen bursars from Thunderer Squadron attended an attachment at JFC Naples and MCC Nisida. The attachment involved talks and presentations from many international service persons from a variety of departments. The aims of this exercise were to allow bursars to:

- Gain an understanding of Action Centred Leadership in an international environment.
- Understand how to manage and enhance the performance of subordinates through observation of serving officers and SNCOs.
- Gain an understanding of British defence policy.
- Gain an understanding of the background to current

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international military operations.
- Learn about the typical organisation structure of an operational NATO unit.
- Be able to communicate logically and clearly with superiors, peers and subordinates though interaction with serving members of NATO's armed forces.
- Develop the preparation and delivery of effective presentations.
- Participate in events of an unfamiliar nature.

**Activities**

The group attended Morning Commander's awareness briefs and briefs on HQ departments and activities, and on operations in Kosovo. At the end of the visit, they gave a well-received presentation to Admiral Westbrook and other senior officers at British Community Centre, with a social in the evening providing excellent networking opportunities.

The cultural component was not neglected, with a visit to the monastery of Monte Cassino, the site of an important battle in the Second World War, ending at the war memorial to reflect on the sacrifices of those who have gone before, as well as climbing Mount Vesuvius and visiting the preserved Roman town of Herculaneum.

**Benefits**

The exercise was extremely beneficial for all the bursars who participated. The insight into Operational and Strategic Command is unparalleled throughout the available opportunities in DTUS. There are relatively few opportunities in DTUS to interface with senior officers and open dialogue with very senior staff such as Lieutenant General Haynes, Admiral Westbrook and CSM Jarebek will not be repeated in any of the bursars' careers for a very long time.

Equally important was the opportunity to mix with officers from the international NATO community. With the increased focus on international cooperation in the UK military the opportunity to experience how these other militaries operate and how a multinational base functions will be invaluable.

*The bursars outside JFC Naples*

**Exercise Typhoon River Wild – an exhilarating morning of white water rafting at the National Water Sports Centre.**

Midshipman Marr reported: "On a relatively early Saturday morning on 10 November 2012, Typhoon bursars were given a fantastic opportunity to head out to the National Water Sports Centre for a day of white water rafting.

As it was a first for nearly all of us, we didn't know what to expect. The main thing on everyone's mind, on a November morning, was the cold. However, we were pleasantly surprised as we were quite warm once we got into it.

After a safety brief, and a quick paddle in the pond learning the various commands, we were straight onto our first bit of white water. The aim of the first part seemed just to get us soaked.

We would slowly paddle towards the drop from the bottom end and then just as the water got close, hunker down on the bottom and lean forwards. The water piled in over your head as the raft went nose down and almost vertical and if the instructor had lined it up right, you even stayed the right way up afterwards.

We had a few runs on the rapids, with lots of 'unintentional' inverting, before heading back to the pond, where most people found themselves swimming back to the pontoon.

It was a exhilarating introduction to challenging pursuits which allowed most of the new intake to become better acquainted with other members of the Squadron. It also exposed the bursars to the wider aims of Adventurous Training within the military. It was a hard but truly worthwhile day."

*Some bursars about to take the plunge...*

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**Inter-Service paddlefest and freestyle kayaking championships**

On 21 July Midshipman Nathan Ling from Typhoon Squadron took part in the inter-Services paddlefest. This event aimed to gather together as many inter-Service kayakers as possible, to facilitate skill improvement and take part in the annual freestyle competition.

The event was held on the river Treweryn with the entire river being used for river-running sessions and the main feature on the upper section being used to deliver freestyle coaching and for the competition.

Saturday consisted of coaching workshops to improve river techniques and learn freestyle moves. Sunday consisted of a morning freestyle practice session where coaching was delivered by Nathan and Sub Lieutenant Stuart Alderson (ex-Typhoon Squadron).

The competition was held on Sunday afternoon where a wide range of competitors from all services took part. All competitors took part in a series of heats where they had the opportunity to show what skills they had. Competitors were judged using a standard scoring system to award points for technicality and quantity of moves with bonus points awarded for originality and comedy. Some of the moves included a flat spin, blunt, blast, cartwheel, split wheel, ariel loop and space godzilla.

The overall results saw Nathan Ling take first place and Stuart Alderson in 2nd place.

*Ariel loop setup*

**A SUCCESS?**

The DTOEES was established to provide enough technical officers and engineers of sufficiently high calibre to meet single Service requirements. Since its inception in 2005, DTOEES has provided 307 engineering and technical graduates from the five-year Scheme pipeline so far. In FY12/13 this provided the Services with 33% of RN engineering officers, 32% of British Army officers joining the four technical corps and 100% of RAF engineering officers[1]. Of those who have graduated from the DTOEES pipeline, most are still at IOT/GES or about to start and 99 have completed IOT/GES, of whom 46 are in productive Service. Initial analysis has shown that performance at IOT is particularly strong during the first term and one exceptional DTOEES graduate won the Sword of Honour from RMAS. Further analysis will be done when more DTOEES students have finished IOT. In addition, work is on-going to track DTOEES ex-bursars' career performance following IOT/GES to enable further validation of DTOEES.

In the last year, 114 students (including 41 master's students) graduated from University, 84 of whom have already started IOT/GES with the remaining due to start IOT/GES imminently. A further 32 have remained at university to complete a master's degree. Of those who graduated, 57% achieved a first class or higher second honours degree, which is on par with the national average. In addition to their university studies, the students conduct a comprehensive training programme of military exercises, adventurous training, attachments, sport and squadron training evenings to develop their leadership, personal development and military skills.

There are currently 306 students at DSFC, and 433 bursars, 32 ISDOs and 18 UY(E) at the DTUS Squadrons. In total, DTOEES is currently supporting 789 serving and potential technical and engineering students.

In sum, the contribution made by DTOEES is a pivotal part of the recruitment of engineers and technical officers. DTOEES is maturing and is now regularly providing the technical or engineering branches and technical corps with over a 100 military aware, technically competent and physically robust officers per annum. Finally, as Captain Naval Recruiting said 2012 "*For the first time since 1994, the RN will virtually meet its engineering officer recruitment targets*".

1 The RAF percentage is a temporarily high figure brought about by the combined effects of recruiting targets, redundancy and Service restructuring.

**GLOSSARY OF TERMS**

| | |
|---|---|
| AT | Adventurous Training |
| DESG | Defence Engineering and Science Group |
| DSFC | Defence Sixth Form College |
| DTOEES | Defence Technical Officer and Engineer Entry Scheme |
| DTUS | Defence Technical Undergraduate Scheme |
| GES | Civil Service Graduate Entry Scheme |
| IOT | Initial Officer Training |
| ISDO | In-Service Degree Officer |
| PFI | Private Finance Initiative |
| RMAS | Royal Military Academy, Sandhurst |
| UY(E) | Upper Yardman (Engineer) |

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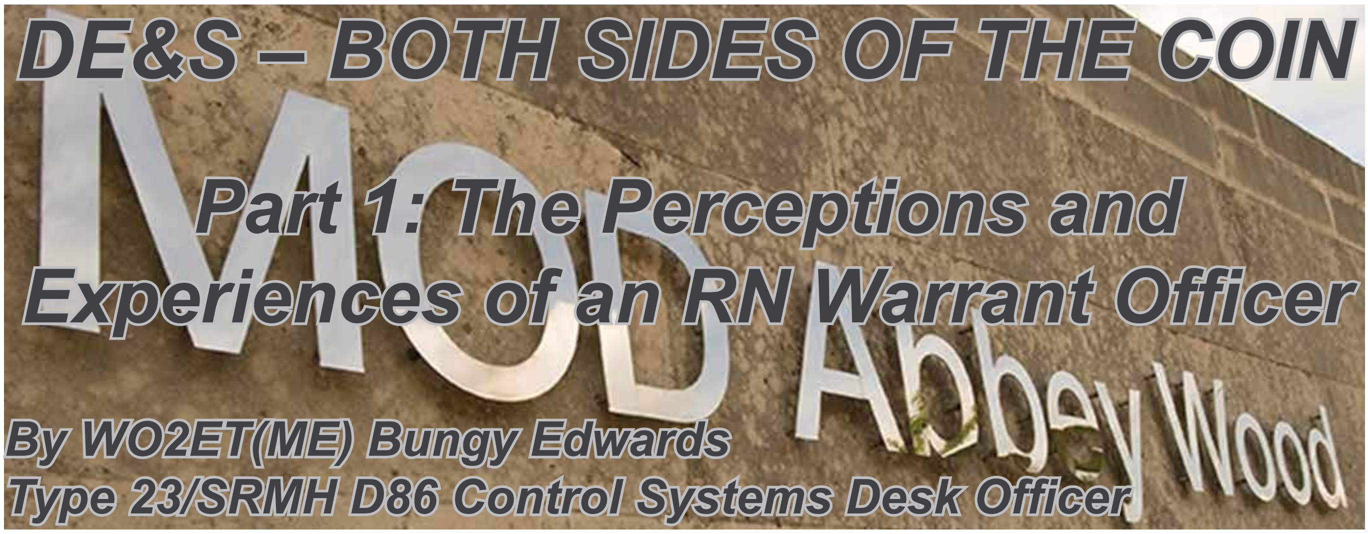
# DE&S – BOTH SIDES OF THE COIN

## Part 1: The Perceptions and Experiences of an RN Warrant Officer

By WO2ET(ME) Bungy Edwards
Type 23/SRMH D86 Control Systems Desk Officer




WO2 'Bungy' Edwards joined the service in 1992 as an MEM2. Having completed Phase 1 & 2 training, he was drafted to HMS Ark Royal where he completed his Task Books and AMCs. Advanced to LMEM(L), he successfully completed the Artificer Candidate Early Selection (ACES) course. Successful completion of the MEAQC, he passed out as an LMEA where he served in HM Ships Invincible and Ark Royal until advancement to CPOMEA. After a shore job at Sultan within MEAQC Divisional Organisation, he volunteered for the M1 job onboard HMS Grafton. A short period at SFM(P) was followed by a stint in HMS Richmond where he gained selection to WO2MEA. On completion of WO2MEAQC he was assigned to MCTA where he was employed as the trials technician for Team 1 (Type 23, LPD, SVHO & LSD(A)). This was followed by his first WO2 sea appointment onboard HMS Portland. He is now employed at MOD Abbey Wood within the Maritime Platform Systems group.

**INTRODUCTION**

I have been asked to write this article because I had a varied opinion of what the Output Business Units at Abbey Wood (ABW) deliver to the Fleet, from my own experiences.

My aim is to explain how I had a very mixed conception of this support organisation and how these perceptions, in many cases, have been unfounded now that I have full visibility of this working environment.

This article is intended to be delivered in two parts; the second part will follow in a later issue and be delivered by a Civil Servant – Mr Darren Butt (ESG-PP) – with his point of view from the Civil Service.

**THE EARLY YEARS**

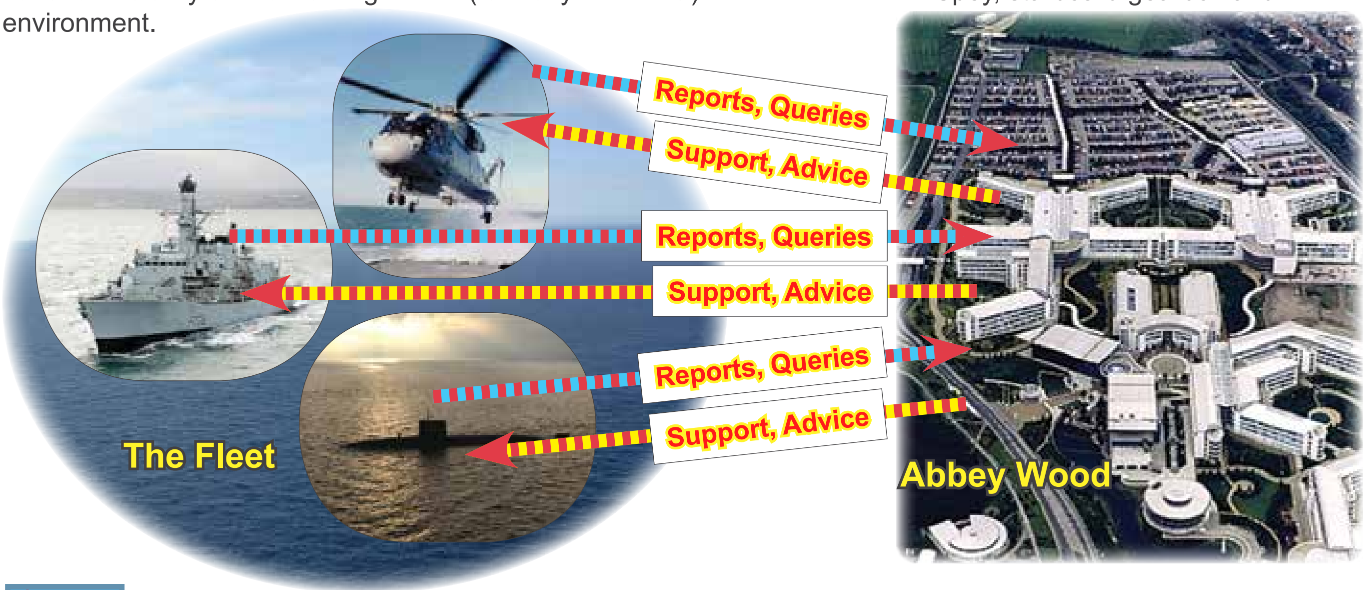
Until promotion to CPOMEA, the first half of my career was very standard with little or no contact with external support organisations such as DE&S Abbey Wood (formerly with DLO).

In comparison with today's ET(ME) branch structure, my experiences are very similar to a newly promoted POET(ME) who is now delivering Operational Capability (OC) at this earlier level. Generally a POET(ME) will have served less time and have less experience than I did, but is expected to deliver OC and liaise with external support organisations and authorities.

My first sea jobs as M1 were onboard HM Ships Grafton (2004–06; pre-Personnel Change Programme (PCP)) and Richmond (2007–08; post-PCP). During these assignments I was quickly thrust into the realms of liaising with Equipment IPTs on a regular basis.

My baptism of fire occurred in Grafton returning from the Northern Arabian Gulf.

Major OPDEFs in quick succession were experienced on my starboard Spey, starboard gearbox and

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starboard propulsion motor. Despite giving me an excellent insight into how this equipment was constructed and functioned, it also meant that I had to liaise and rely heavily on the support I received from the relevant desk officers within the EIPTs.

After some time all of these defects were rectified, however the support I received from ABW was of a varying standard, and caused me much frustration when trying to resolve these defects.

I quickly realised which desks I could rely on for swift credible advice and which I would take a more reserved view on.

Much of my time in Grafton was further hindered by the Reduced Stores Support (RSS) status which was applied to the vessel because of its readiness state and current tasking. This ultimately meant that stores would only be released for OPDEF or Health and Safety related issues.

In hindsight, I was a young and eager CPOMEA and very conscious of the materiel state of the machinery under my charge, to the extent that I took it as a slight on my engineering ability when any of my equipment wasn't available to command. The varied level of support and RSS status imposed fuelled my ever-diminishing opinion of ABW.

Advanced to WO2MEA, I found myself working as the trials technician for MCTA Team 1. This was a more mature experience as I was surrounded by very senior members of the branch who could rein in my eagerness when required.

Following MCTA I was assigned to HMS Portland (2009–12) as PROPMAN and this is where the outputs from ABW had a major impact on my day to day business. Operating outside of my comfort zone with regards to my ADPROP and controls background, I was quickly trying to manage an entire department's worth of equipment, some of which I had very limited knowledge of.

Trying to keep all of the 'plates spinning' and the ship on programme was very demanding. It was clear that all organisations were pulling in the right direction to maintain the ship, but I still couldn't shift this uncomfortable view about the overall service provided by ABW.

Whilst at Special Sea Dutymen (SSD) on one occasion, the MEO heard me airing my frustrations about the support received from one of the EPT desks. He tried to explain to me that my view was very blinkered and that I needed to experience employment at ABW to gain a better understanding of this organisation. I remember listening to the MEO and we both agreed to disagree on that occasion. During the end of my time in Portland I started to look at shore jobs, and eventually agreed to take up a role in ABW.

One of my final memories onboard is overhearing the MEO on the phone discussing his anger about something ABW had done which directly impacted him. I couldn't resist the opportunity to knock on his door, and whilst saying my farewells, I mentioned that his view of ABW had changed since he had been onboard. He acknowledged my comment in the manner it was meant and wished me well on my way – although those aren't the exact words he used!

**ABW EMPLOYMENT**

After a dislocated handover and some well deserved leave, I was ready to join ABW and undertake whatever challenges it had to throw at me, although it was with some reservation.

During my handover I was surprised at the number of Civil Servants on the floor plate that were delighted to see another uniformed member of staff arrive. It was clear that this wasn't just a standard warm welcome, but that they were genuinely happy to have another RN member of staff around, They wanted to draw on my experiences in the Service, particularly as an experienced operator and system manager. Looking across the floor plate, it was clear that there were comparatively few personnel in uniform and this number is sure to reduce further in the future.

When introduced to the personnel within my new team, it was clear to see that the majority of the individuals did not have a Marine Engineering background. The team comprises a mix of Civil Servants and ex/serving military staff. Besides the Group Leader (Cdr(ME)), I am one of two members of the team with a pure Marine Engineering background.

The remaining limited numbers consist of a varied mix of Weapon Engineers (RN and RFA) along with a couple of ex-RAF engineers.

Electrical systems vary from High Voltage, Low Voltage, Electric propulsion systems, Intricate controls systems to software driven Platform Management Systems.

The wealth of knowledge and understanding of their individual equipments by the desk officers is second to none.

Having worked on DII previously, I presumed that setting up my IT services would be a simple task, seeing that the IT request had been submitted some six weeks prior to my arrival. The obligatory delay occurred and although I had access to DII, none of the applications and accesses I required to function in my new role were permitted at this point. I think it was a good few weeks before I had all of my

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programs accessible, but the essential applications were available within the first week of starting.

The first revelation I received was when I sat down with my Line Manager (LM) to discuss my Terms of Reference (TORs). I presumed that my core role was to be the Subject Matter Expert for the equipment associated with my desk, whilst supporting the fleet through a wide range of defects and enquiries. Surprisingly, it soon became apparent that my main focus was to look at the equipment within my remit, considering equipment availability and future supportability options, with a view to overcoming any limitations imposed by obsolescence. Other TORs were discussed and rectifying ships defects didn't really feature on the list. When I questioned this with my LM, it was explained to me that SFMs and COMs were responsible for rectifying ships defects.

Whilst I have enabling support contracts, these are geared around the future supportability of the equipment within the scope of the contract. Whilst we utilise some of this for Technical Support Hours, this is quite limited and should be used sparingly, once SS, SFM, COM and my expertise has been exhausted.

The routine day-to-day work within an EPT is fairly straightforward. Responding to emails and signals is commonplace, however many signals are for stores related to items that are obsolete; this is mainly due to technology advancement, driven by consumer markets and the availability of components to support controls and surveillance systems.

This activity can be resource-intensive as each individual item has to be cross-referenced, within several different IT applications, from a maker's part number or NATO Stock Number to ascertain whether an alternative item already exists. If not, then investigation is targeted towards the Original Equipment Manufacturer (OEM). In many cases, the OEM will have discontinued their production and updated their inventory with a newer product. In this case a Technical Enquiry will have to be sent to one of their support technicians and then await a response.

Considering the application that much of this equipment is utilised for, it is necessary to ensure that all safety considerations and precautions are included into the replacement component to ensure it is safe and appropriate for the working environment where it will be employed.

Once a response is received from the OEM, and the Project Manager has satisfied himself that the replacement item meets the Fit, Form and Function of any alternative item, then a quote can be obtained and the inventory team can go ahead with the purchase, either on a running contract if available or via Government Procurement Card, if within the limitations of use.

The lead time for many items can be in excess of six months as most companies no longer maintain any form of stock holdings and the item will need to be manufactured to meet requirements. This seems to be quite a protracted way of replacing items, but manageable none the less.

Non-patternised items are much more taxing to procure. This is simply because, in many cases, there is very little information held regarding these items and all of the research has to be conducted from scratch. This, coupled with a heavy manpower gap in the Logistics Support (LS) section, means non-patternised items can take a considerable amount of time longer to source.

Overcoming system obsolescence is also a major task which is very time consuming. Identifying alternative sub components as mentioned above is fairly standard business, however, system based obsolescence demands much more effort. Once a system or master equipment has been identified as obsolescent, which could be due to availability of components or even the OEM going out of business, then an alternative arrangement must be sourced. This could be conducted by identifying a company which is capable of supporting the current equipment fit, with only a few minor changes, or by completely changing the equipment to a new design.

In either case the process to reach the end result could take a number of years. There are many factors which influence this timescale, including:

- The turnover of manpower (particularly uniformed staff) within the desks disrupting the continuity of such projects.
- The availability of alternative systems and parts.
- The ability to integrate identified systems into the warship operating context.
- The opportunities to trial the alternative equipment in order to make a fully formed decision on whether it is to be introduced into service.
- The commercial and assurance processes which have to be followed robustly.

The technical support to ships and units along with resolving obsolescence could be a full time job in itself. However there are a variety of other commitments each Project Manager has to deal with including the following:

- Safety Case Reviews.
- Reliability Centred Maintenance Studies.
- BR and IPC reviews.
- Various application user workgroups.
- S2022 and S2022a management.
- Financial reporting.
- Performance reporting.

Much of this work could easily fill a diary but has to be carefully managed and prioritised within the resources available.

Other work which can be very time consuming is attending the plethora of future project meetings.

In general when new equipment is introduced, or existing equipment upgraded the task will be placed upon an external contractor working

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on behalf of the MOD. Project Managers still need to maintain a close relationship with these working groups to ensure that any proposals made encapsulate all of the requirements for the end user.

I mentioned earlier that the LS team were suffering from manpower gapping. As you would imagine, this isn't limited to the LS group but appears across every section within ABW. For many different reasons, manpower gaps are appearing more and more across the site. Civil Servants can move between positions on a two-year cycle if they wish to, however replacing a gapped desk with a Suitably Qualified and Experienced Person can ultimately mean that the position remains vacant for a considerable length of time until the right person is employed.

This manning situation is further compounded by the ever-increasing gap within the uniformed staff plot. The current position with regards to RN manning is a separate article within itself; ABW features comparatively low in the manning priority list and results in uniformed staff gaps.

It's not all doom and gloom though, as it is pleasing to see that many Civil Servants of all grades stay in their positions for extended periods of time, offering stability and continuity within their respective work groups.

The last point that causes me a degree of concern about the organisation is the variation within the output units in the way that equipment boundaries are addressed. Some Project Managers take a wider systems- based approach to their equipment, however other desks are not fortunate enough to take a similar approach and have to focus purely on single equipments to deliver the support that is required. This may be the result of the comparatively high quantity of defects these equipments experience, along with manning gaps as stated previously. In every case, each desk is doing its utmost to deliver the required support to maintain their equipment, now and in the future.

**THE FUTURE**

Very much like the Royal Navy, the MOD and in particular ABW always seems to be in a state of transition. In today's fiscal constraints, senior managers are always being asked to streamline their production and look at ways of conducting the same business outputs at a cheaper cost.

This is sometimes to the detriment of the service ABW is trying to deliver, but unfortunately it is necessary in today's climate.

From the meeting and forums I have attended whilst in post, the next step forward for DE&S and ABW in particular is likely to be either Government Owned Contractor Operated (GOCO) or a transition to "DE&S+".

In every meeting/forum I have attended where the GOCO subject has been mentioned, I have been informed that this should have little or no impact on the way ABW delivers its outputs and, as far as uniformed personnel are concerned, is merely a managerial shake-up where only 1* and upwards will be affected.

DE&S+ is more geared around restructuring DE&S as it already stands in order to make it more streamlined, efficient and ultimately better.

With regard to uniformed manning, the majority of the posts within ABW are for WO2 upwards. Since the advent of PCP and the sheer nature that OC is now being delivered at a lower level, could it be feasible to de-enrich some of these positions to CPOET or even POET(ME)? My concern with this would be the fact that a WO2 has a level of separation from ships' staff maintainers and is fully capable of liaising with senior managers (MEOs, Platform Managers, Class Output Managers etc) fluently and confidently; this may not be the case for CPO/POs.

The experience gained by a WO2 is sufficient to enable him or her to make policy changes/amendments which could have significant impact on ships systems.

I am sure the current manning plot for uniformed staff at ABW will change drastically and I am somewhat intrigued to see what it will look like in the future.

**SUMMARY**

Since PCP took effect, the ET(ME) of today's Navy is delivering Operational Capability (OC) at a much earlier stage in his career.

I hope that by giving my personal experiences and limited interaction with ABW, during the first half of my career, correlates with the same position a newly advanced POET(ME) today finds himself in.

By highlighting the extensive workload required to fulfil the role of an Equipment Project Manager or desk officer, I wish to give those serving on the front line and requiring our support on a regular basis an appreciation of the amount of work a simple query may generate. This hopefully goes some way to explaining that the output from ABW is very hampered through the many different processes which have to be followed to ensure the work is completed to the correct standards.

I would urge ships teams to arrange liaison visits to ABW (via ABW Fleet Liaison Manager) to enable maintainers to start/continue building relationships with their desk officer counterparts and suggest that patience is adopted whenever the situation allows it.

**GLOSSARY OF TERMS**

| | |
|---|---|
| ABW | Abbey Wood |
| EPT | Equipment Project Team |
| GOCO | Government Owned Contractor Operated |
| LM | Line Manager |
| LS | Logistics Support |
| OC | Operational Capability |
| OEM | Original Equipment Manufacturer |
| PCP | Personnel Change Programme |
| RSS | Reduced Stores Support |
| SSD | Special Sea Dutymen |
| TORs | Terms of Reference |

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# NAVAL ENGINEERING

Welcome to another edition of *Lessons Identified*. The series authors are Lieutenant Commander Duncan McDonald (FLEET-CAP SS OSG SO2) (GS) and Lieutenant Scott Redpath (FLEET-CAP SM E ASSUR SM SO3) (SM), to whom any immediate queries should be addressed.

The above named officers and Commander Philip Parvin (SM) (FLEET-CAP SM E NPOS SO1) are the current Navy Command HQ sponsors for this series of articles; they welcome feedback or material for future editions of *Lessons Identified*.

# — LESSONS IDENTIFIED —

## HMCS CHICOUTIMI FIRE 2004

### Original report by Mike Salmon, AMEC

*The report below[1] has been taken from the AMEC (RSD) Operational Experience Monthly Report that is produced for the Defence Nuclear Safety Regulator. It has been reproduced here with permission, although slightly cut down for this publication. The report contains a lot of information that all submariners should now be instinctively aware of due to training and education that was driven by this event. It does however still make for an interesting read and it cannot be more strongly encouraged to re-educate yourself on the sequence of events that occurred on HMCS Chicoutimi and the lessons learnt.*

1 AMEC RSD Operational Experience Monthly report, Issue 58.

**INTRODUCTION**

During the late morning of 5 October 2004, whilst surfaced in open sea conditions en route to Canada, HMCS Chicoutimi had an ingress of water through the conning tower, substantial enough to trigger a series of electrical events that culminated in an electrical arcing of the main power cables and fire in the CO's cabin. The fire spread rapidly to adjacent areas and the deck below, causing significant damage to submarine systems and loss of all power. The crew contained and suppressed the fires and sought help from outside agencies. Several hours later an unrelated fire occurred in an oxygen generator in the weapons storage compartment that was short-lived and caused no further injuries or damage. In total, the crew sustained nine casualties, including one fatality. Restoration of onboard systems commenced and once outside assistance was rendered, medical care and evacuation was implemented. The submarine was taken in tow on 7 October and was returned to Faslane on 10 October.

**BACKGROUND**

HMCS Chicoutimi was an ex-Upholder Class Royal Navy diesel-electric submarine sold to Canada. The Canadian Government signed a contract for the acquisition of the four Upholder Class submarines from the Government of the United Kingdom in 1998.

The submarine was transiting on the surface and entered a low-pressure system that was generating gale force winds and building significant seas. Whilst conducting an emergent repair on the outer lid of the conning tower to allow dived operations, a wave welled up around the fin causing significant water ingress into the submarine starting a chain of events which led to the fire.

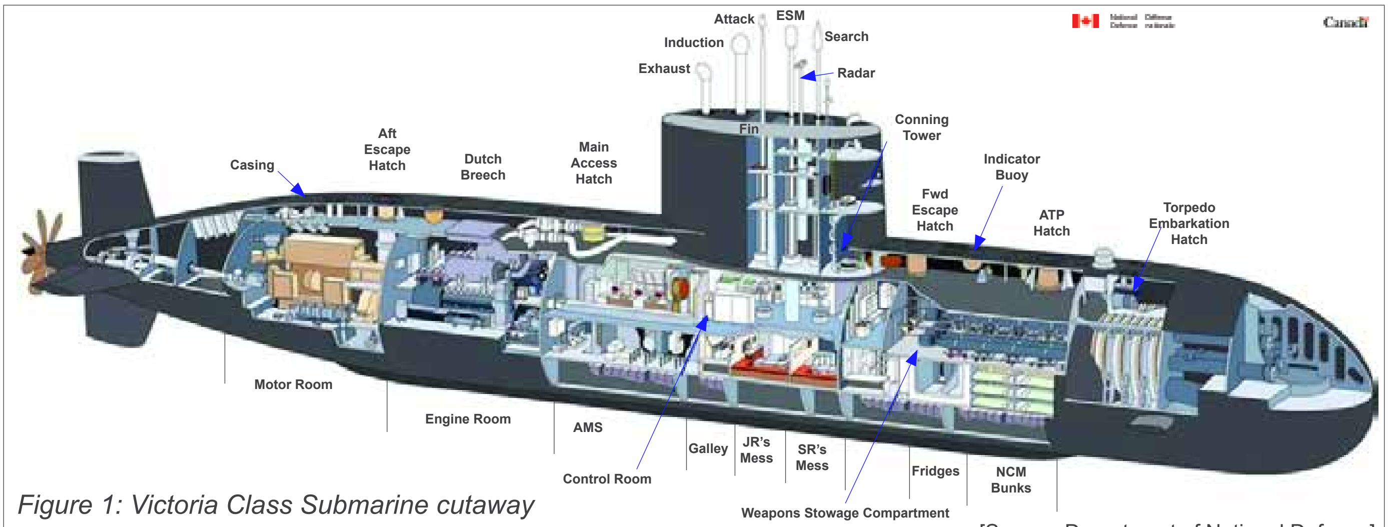


*Figure 1: Victoria Class Submarine cutaway*

[Source: Department of National Defence]

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## SEQUENCE OF EVENTS

HMCS Chicoutimi's transit would normally have been dived but a late change in the submarine's routeing was ordered by the Submarine Operating Authority at short notice and required the boat to remain on the surface until the afternoon of 5 October. The BOI explained that, on the surface, Victoria Class submarines will generally run 'shut down' in accordance with applicable 'standing orders'. In this state the Officer of the Watch and a lookout are present on the bridge in the fin above the conning tower (Figure 1) and at least one of the conning tower lids, which isolate the Control Room from the sea, will always be shut. However, a defect on the upper lid vent, which had been reported on the morning of 5 October, needed to be repaired before the submarine reached its intended dive position later that afternoon. The CO checked the sea conditions and ordered the boat to be 'opened up' at 1052 to commence the repair, stating his intention was to move to a single lid operation, but minimising the time both lids would be open during the repair.

By noon that day HMCS Chicoutimi was approximately 100 miles northwest of Ireland, surfaced and 'running open' (both hatches in the bridge fin open) when an estimated 2000 litres of seawater entered the vessel. The seawater was mopped up and a survey and inspection undertaken, but two hours later electrical shorting led to a major fire and loss of all electrical power and propulsion, leaving the submarine to drift in heavy seas. Initial rescue by helicopter and a Royal Navy frigate HMS Montrose, which arrived the following day at 11:28, were decided against on account of the rough sea conditions. It was not until 17:30 that three of the nine crew members affected by smoke inhalation were airlifted by a Royal Navy helicopter for medical treatment after their condition deteriorated.

## UPPER LID VENT DEFECT

The upper lid vent is a hand operated spring-loaded valve (Figure 2) that is used every time someone is cycled through the conning tower; due to its location it is prone to fouling up by debris and salt deposits. Such items typically require regular attention (indeed a vent defect had occurred whilst the submarine was on earlier sea trials). On the day of the accident the vent required disassembly and cleaning. On reassembly, the repair team used a hammer and screwdriver to tighten the locknut as they did not have an appropriate tool close by. After breaking a couple of screwdrivers one of the repair team proceeded below for additional tools, which is when the water ingress occurred.

> Upper lid vent defects were a common occurrence given its operating environment, so would have required appropriate Examination, Maintenance, Inspection & Testing prior to sailing

With the prospect of deteriorating weather forecast, the CO saw the opportunity to deal with the defect quickly. The CO testified that on the morning of 5 October his intention was to run opened up, but to minimise the amount of time both hatches were open by having one lid shut as much as possible; however this was not clearly communicated to the Petty Officer supervising the repair.

It was the CO's overall responsibility to weigh the risks of water ingress and to mitigate the possibility with his on-watch crew in accordance with the prevailing conditions. Just before the ingress of water, none of the on-watch crew personnel were concerned about the risks in running opened up in that environment (four metre seas and 35 knot winds). The CO did not foresee that a wave much higher than four metres was to form and envelop much of the fin and overflow into the tower[1].

Furthermore, previous experience of water ingress through the conning tower on other submarines might have led to a culture of belief that a serious fire is unlikely to result[2].

In the case of HMCS Chicoutimi, the fire did not start until two hours after the water ingress. Evidence indicated that while the cables outboard of the Captain's cabin, visible through the opening on the false bulkhead (Figure 3), were inspected following the ingress, the cables under the CO's bunk were not, due to inaccessibility. With up to 30º roll being experienced, the saltwater that could not be

1. Board of Inquiry Report – Part II Findings, para 117 – 119.

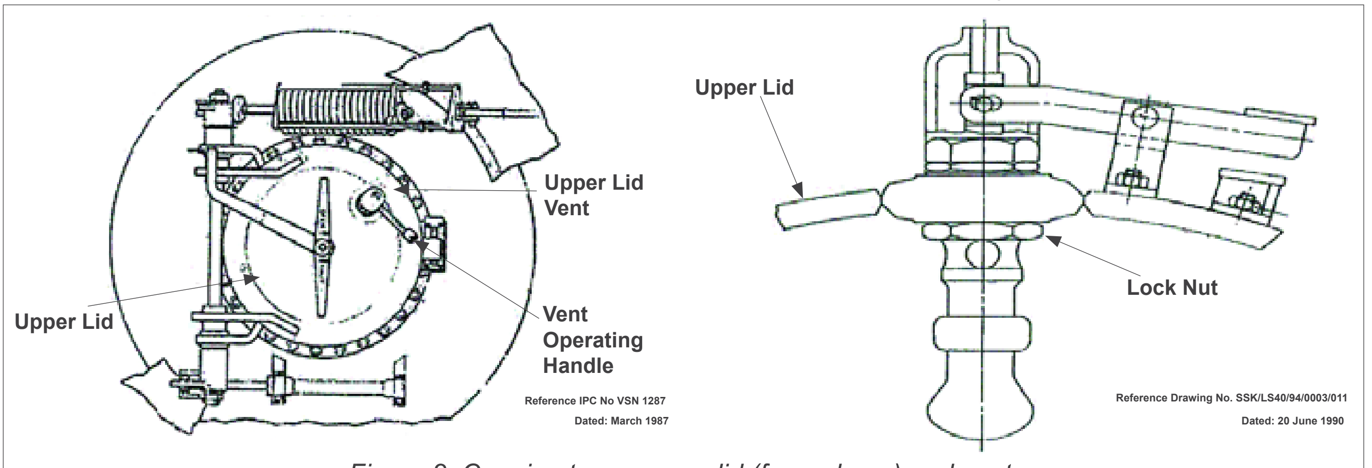


*Figure 2: Conning tower upper lid (from above) and vent*

[Source: BOI Supplementary Report]

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*Figure 3: Looking through false bulkhead in CO's Cabin (port side)*

[Source: BOI Annex D]

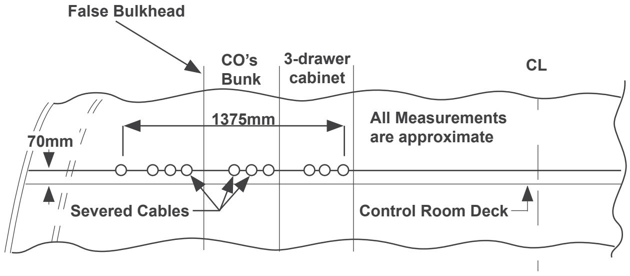


*Figure 4: Part Bulkhead 35 looking forward*

[Source: BOI Report]

cleaned up in inaccessible areas of the Control Room caused repeated immersion of the power cable connector insulation material underneath the CO's bunk. This problem went undiscovered so that there was no warning of the impending threat of fire.

## PREVIOUS ACCIDENTS INVOLVING FLOODING INDUCED ELECTRICAL FIRES

On 21 May 2002, whilst cruising on the surface in open sea, recharging its batteries, USS Dolphin was involved in a sea flood[2] when a torpedo door shield gasket failed. Due to high winds and 3m ocean swells, approximately 70 – 85 tons of seawater entered which was very close to the boat's reserve buoyancy. The flooding shorted electrical panels and started fires, which were beyond the ability of the crew to control, and the ship was abandoned.

On 24 April 1988, whilst USS Bonefish was submerged in an exercise 160 miles off the coast of Florida, seawater began leaking onto cables and electrical buses in a battery supply cableway[3]. Electrical arcing between cables caused an explosion which flashed into a fire within minutes, with temperatures in the battery spaces reaching 650°C. The heat was so intense that it melted the shoe soles of personnel on the decks above. Bonefish was surfaced and her crew was ordered to abandon ship.

## ORIGIN AND CAUSE OF HMCS CHICOUTIMI FIRE

The origin of the fire was outboard of the CO's cabin under the bunk aft of Bulkhead 35 where the main power electrical cables were found severed in close proximity to the deck (Figure 4). The cables in question were connected to bulkhead penetrators that ran through the bulkhead (from the forward battery switchboard to the main propulsion switchboard in the motor room) The severed and damaged cables can be seen in Figure 5.

The BOI found that an electrical arc in the main power cables caused the fire in the CO's cabin, which then quickly spread to the electrical space below. The arc occurred in the joints between the main power cables and bulkhead penetrator and required a failure of the insulation around the area where the arc occurred, as well as a conductive medium where the fault current would flow. The BOI's technical investigation considered both aspects and focused on the insulation around the connector joints.

Although little objective evidence could be provided on the design intent for the watertight integrity of the main DC cable connectors, the most probable cause of the insulation failure is that it was not designed to withstand immersion in water. The Board did not have conclusive forensic evidence on the failure of the red insulating

2. Wikipedia article on USS Dolphin (AGSS-555). (accessed 25 January 2013).

3. Wikipedia article on USS Bonefish (SS-582). (accessed 25 January 2013).


*Figure 5: Location of three severed cables in CO's Cabin and a failed main cable*

[Source: BOI Annex D]

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material around the connectors. The insulation, as installed, would have provided splash protection and a degree of watertight integrity that would have prevented an immediate arc from occurring. Based on evidence received by the Board, there was likely water ingress along the interface between the insulating boot around the connectors and the penetrator. Low intensity arcing may have then occurred which damaged the insulation, allowing the arcing to increase over time, but without tripping the main power breakers. Ultimately, a short-circuit path was completed through residual water in the Control Room. When the 'catastrophic arc' occurred, the current flow did trip the main power breakers, which was reported by the Machinery Control Console operator.

The intensity of the main electrical arc and the high temperatures of the ensuing fire under the CO's bunk are indicated by the severing of the three high energy cables and the two holes melted in the metal of 1 Deck (Figure 6). Molten aluminium was found throughout the electrical space on 2 Deck below, and on 1 Deck under the CO's bunk. The electrical space fire was caused by the fire in the CO's cabin above; pellets of molten metal (probably aluminium, steel and copper) dropped down and ignited combustible materials.

**DAMAGE CONTROL EMERGENCY RESPONSE**

Personnel saw the ignition of the fire from the Control Room, which was quickly identified as electrical and all power was isolated. The ignition temperature was extremely high but evidence in the fire investigation report shows that the fire was brought quickly under control even though large amounts of smoke were produced. The general alarm was sounded and personnel broke out Emergency Breathing System (EBS) masks almost immediately. A fire hose was used for the fire in the CO's cabin, rapidly bringing it under control, but the nozzle shot off after it was shutdown, potentially jeopardising subsequent efforts to control fires. The fire spread into the electrical space directly below on 2 Deck, filling the area with black smoke within seconds, reducing visibility to zero, but this also was quickly extinguished with portable $CO_2$ extinguishers by two crew in the Junior Rates' Mess, who quickly donned masks[4].

The speed of the fire and its effects hindered damage control efforts. Main electrical cables were destroyed, forcing crew to deal with follow-up actions without power, ie using techniques not provided for in SOPs, and which therefore took more time to carry out:

- The low-pressure blower was not available for smoke clearance.
- Trim pumps were not available to recharge the fire main with water for area overhaul/to fight the second oxygen generator fire.
- Communication both within the submarine and externally for requesting emergency assistance was difficult and limited to portable battery operated radios/phones – this did not improve until the arrival of HMS Montrose the next day[5].

Nevertheless, with limited resources, the crew took action to prevent the spread of fire, to work around communication problems and to exploit all equipment that was available.

A number of concerns were raised about the emergency breathing system (EBS) in the BOI report. A fundamental issue for those who suffered smoke inhalation was the ability to "quickly get to a mask and get it on". In some cases personnel tackled the fire prior to donning a mask.

There was also testimony[6] that criticised the EBS provisions and design which included:

- Insufficient masks stowed in compartments close to the fire (Weapons Storage Compartment and 2 Deck forward of Bulkhead 35).
- Lack of masks fitted with long hoses restricted crew movements.
- EBS couplings were located flush with the deckhead, so difficult to locate in reduced visibility.

4. BOI report, para 155 – 160 and 166 – 175.
5. BOI report, para 233 – 242.
6. BOI report, para 195 – 199.


*CO's cabin* *Electrical Room – metal drops from above*

*Figure 6: Extreme temperatures close to the fire's origin*

[Source: BOI Annex D]

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- EBS provisions were inadequate for fleeting between the Control Room and the bridge in the tower, so personnel had to remove masks in a smoke-filled tower acting as a chimney.

- Regulator air flow was not automatic and the regulator was susceptible to detachment.

The BOI recommended[1] the development of more realistic firefighting training in 'mock-ups' to include both donning and use of EBS in blackout conditions.

**CASUALTY/MEDICAL RESPONSE**

Approximately one hour after the fire was put out, the nine casualties were reported as stable but that evacuation was desirable. However, offers of additional oxygen via helicopter were turned down because of assessed environmental conditions.

The injuries to the crew member who died were assessed[2] as having been caused by inhalation of hot gas and smoke, and he is likely to have sustained these injuries when he transferred from Damage Control HQ in the Senior Rates' Mess to the Control Room. Initially he would have therefore been close to the hot gases when the fire spread into the electrical space. As with others, he did not locate a mask. When in the smoke-filled Control Room, he called for a mask, but initially had to share with the CO. The CO returned to fire response after another mask was provided, but this is likely to have detached when he fell. "*He would have been breathing heavy smoke for at least five minutes*"[8]. Another mask was provided and plugged in for him but he needed help to operate the mask purge valve. He was eventually moved to the JR Mess where the CO believed his condition to be stable, if not somewhat improved.

1. BOI Report, para 211.
2. BOI Report, para 255 – 256.

In fact the amount of respiratory damage could not have possibly been known to anyone onboard, and the injuries would eventually lead to deterioration and his death the next day. There were inherent medical equipment limitations onboard and although the need for more oxygen/ evacuation of the casualties was recommended to the CO, such transfers were ruled out because of the environmental conditions.

The following morning the weather had still not abated and the CO determined the best course of action was still to wait for the arrival of HMS Montrose.

When HMS Montrose arrived, the decision was made to transfer oxygen, drugs and a doctor aboard. Subsequent examination confirmed that the three casualties required urgent attention and transfer to medical care. A transfer from the fin to a helicopter occurred late afternoon, still in rough seas, but a crew member was declared dead on arrival at hospital in Sligo, Ireland.

It is worth noting that in a paper to the British Medical Journal[3], the doctors who treated the survivors of the 1985 Manchester airport fire highlighted the potential problems caused by delayed reaction to smoke inhalation (see previous Issue 32 of this monthly report). Although initially only one smoke inhalation victim at Manchester required treatment in intensive care, a number of other individuals developed serious breathing difficulties in the days after the event.

3. O'Hickey, SP et al: *Manchester Air Disaster*, British Medical Journal, Volume 294, June 1987, pp1663-1667.

**KEY ISSUES**

The main underlying event causes of the HMCS Chicoutimi fire are summarised in the table below, grouped according to the three broad reporting streams of People, Plant and Process. Each cause is then identified as Major (red shading) or Significant (yellow shading) depending on the importance of its contribution to the progression of the accident:

| PEOPLE | APPLICABILITY TO THIS INCIDENT (MAJOR/SIGNIFICANT) | |
|---|---|---|
| SQEP/Training | HMCS Chicoutimi had inferior surface handling characteristics compared with the class of submarines that the CO was familiar, yet training did not specifically address these differences, in particular with regard to operating 'opened up' on the surface. Furthermore, due to Upholder Class submarines being withdrawn from service with the Royal Navy several years before transfer to Canada, there were few experienced officers to pass on knowledge and experience. | M |
| Commercial/ Programme Pressure | Despite deteriorating weather, the CO decided to attempt a quick repair of the upper lid vent at sea rather than returning to port. | S |
| Communication | The CO's intent to operate with the lower lid shut as much as possible during the repair on the upper lid vent failed to be adequately communicated to the repair team, leaving the Control Room open to the sea environment. | M |

| PLANT | APPLICABILITY TO THIS INCIDENT (MAJOR/SIGNIFICANT) | |
|---|---|---|
| Design Flaws/ Defence in Depth | The insulation between the DC cable connectors and the bulkhead penetrators was not designed to withstand long-term immersion in water.<br>The upper lid vent mechanism (a hand operated spring-loaded valve), which is located on the outside of the submarine, is prone to fouling up with debris and salt deposits; this meant that it required regular unplanned EMIT. | M |
| Maintenance/ Plant Defects | There were known reliability problems associated with the upper lid vent operation within its working environment. | M |

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| PROCESS | APPLICABILITY TO THIS INCIDENT (MAJOR/SIGNIFICANT) | |
|---|---|---|
| Risk Assessment/ Understanding | There was a failure to fully recognise the hazard from seawater ingress in terms of both its likelihood, given the at-sea conditions at the time, and the potential consequences of a serious fire. | M |
| Learning from Experience | The lack of understanding that significant seawater ingress could lead to a serious fire was based on a limited scope of experience involving water ingress through the conning tower, despite other operating experience of flooding induced fires on submarines USS Dolphin and USS Bonefish. These involved accidental seawater ingress which led to electrical arcing in power cables and serious fires requiring crew to abandon ship.<br>The delayed effects of smoke inhalation had been highlighted previously by the 1985 Manchester airport fire. | S |
| Incident Reporting | The BOI found no evidence of formal incident reporting for the upper lid vent defects which were relatively common; this might have led to longer term corrective action. | S |
| Emergency/ Contingency Arrangements | Design provisions to deal with an on-board fire emergency response (smoke clearance, communication, EBS equipment) were inadequate, as were ships SOPs; these might have been exposed had more realistic emergency training scenarios been practiced. | M |

# BZs

**Congratulations to the RN Engineers who have recently received honours and awards:**
**<u>In the 2013 New Year's Honours List</u>:**

**Appointed as Knight Commander of the Most Honourable Order of the Bath (KCB):**

Vice Admiral A.D.H. Mathews CB

**Appointed as Companion of the Most Honourable Order of the Bath (CB)**

Rear Admiral S.R. Lister OBE

**Appointed as Officers of the Most Excellent Order of the British Empire (OBE):**

Commodore R.W. Mason
Commodore J.M. Slawson ADC

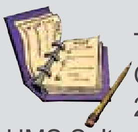
**Appointed as Member of the Most Excellent Order of the British Empire (MBE):**

Warrant Officer 1 (Air Engineering Technician) D.A. Rowlands

**<u>Award of the Meritorious Service Medal (MSM)</u>:**

WO1ET(WE) A.P. Crowe   WO1AET T.J. Roland   WO1ET(ME) M.J. Rowlinson   WO1ET(ME) J.G. Smith

## DIARY DATE: AIR ENGINEER OFFICERS' CONFERENCE 2013



The Air Engineer Officers' Conference 2013 will take place in HMS Sultan on Wednesday 17 July 2013. Commodore Toy, MAA Head of Cert & Reg, will give the Welcome Address and the conference is honoured to have CNEO, Rear Admiral Lister, as Keynote Speaker.

Titled "*Capability through Engineering Excellence*", the conference will focus on "*Sustaining a Capable, Effective and Professional Air Engineering Cadre; to meet the Navy's needs now and in the future.*"

The conference is open to all serving and reserve RN Air Engineer Officers as well as Warrant Officers of the Air Engineering specialisation. There will be an Icarus party on Tuesday 16 July 2013 for those staying in the Wardroom and a Mess Dinner on the evening of the conference for all delegates. Rear Admiral Lister will attend the dinner and will be joined by ACNS(A&C), Rear Admiral Harding, as Guest of Honour.

Further details including costs, accommodation and the conference booking process can be found on the website below. Any queries regarding applications for the conference should be directed to SOAE, AEO Conference 2013 Secretary, Daedalus Building, Royal Naval Air Engineering & Survival Equipment School, HMS Sultan, Gosport, PO12 3BY Tel: 02392 542612 Mil: 93843 2612, Email: sultan-soae@fleetfost.mod.uk, GAL: SULTAN-SOAE

Website: http://sul-r-web-001.sul.dii.r.mil.uk/departments/rnaess/aeo_conference_2013/conference.html

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# WR21 GT: TRAINING FOR THE FUTURE

## By LET(ME) Ben Williams
## HMS Sultan, WR21 GT Training

LET(ME) Ben 'Bungy' Williams joined the RN as a MEM2 in June 2005. After initial training at HMS Sultan, he joined HMS Gloucester, gaining experience mainly in propulsion systems, and took part in the 'First In, Last Out' evacuation of UK nationals from Beirut. Qualifying for promotion to LET(ME) in May 2007, he was drafted to HMS Dauntless after completing LETQC, bringing the ship out of build as a member of M1G section, working directly with the WR21 GT. In September 2010, he joined HMS Sultan's propulsion section in Raper Block, and used his seagoing experience of Type 45 and WR21 to assist in the development of Type 45 ME training, and in particular WR21.

**BACKGROUND**

The Rolls Royce WR21 Advanced Cycle Gas Turbine is the chosen engine for the Type 45 destroyer. Originally a joint venture between the USN, France and RN, the Royal Navy is now the sole operator of the WR21, with two seats in each of the six ships. As the name suggests, the output achieved by WR21 is approx 21.5MW of generating capacity, or in old money, 26,400shp each.

Given the advantages of the advanced cycle (intercooled, recuperated) technology, the WR21 presents significant fuel savings across the whole power range when compared to existing RN gas turbines, whilst still delivering excellent performance for the large Type 45 destroyer.

The chosen training solution for Type 45 Marine Engineering was presented as a purely synthetic system, designed to be facilitated by HMS Sultan staff and encourage own-pace learning, whilst enhanced by facilitator moderated discussions on given topics. The same was also true for the WR21 training at all levels, operator and maintainer alike.

This approach was practical in many respects, as the level of detail in the media presented as part of the courseware for WR21 was very high. The personnel on ME70 (Type 45 PJT) and ME292D (Type 45 Propulsion maintainer) were presented with excellent cut-away animations of the engine and its construction, external components and maintenance tasks along with many other useful tools. The bulk of the animations are also interactive, for example, carry out remove and replace a combustion can (along with a multitude of other tasks), for which the media was also very useful for personnel to learn the procedure for this potentially essential maintenance. To complete these tasks, the correct isolations and tooling must be employed, along with the appropriate permissions to carry out the required work, so it was clear that the system was a very good start and alternative to the old 'from a PowerPoint' approach that was in place for previous equipment. The synthetic training was backed up by the use of the Type 45 IETM, which would support the procedures for maintenance tasks and also give detailed information on WR21 itself.

**CONCERNS**

What was quickly noticed from the pilot ME292D and subsequent courses, and eventually in the Fleet, was that the level of knowledge and practical experience given to personnel on these courses was not adequate. The flat screen synthetic solution does not easily correlate to ME maintainers as the theory-based knowledge was not being backed up with workable practical skills, so this approach to WR21 training was not making the grade for deep level maintainer courses. For example, Spey training incorporates well blended practical aspects and running of a working engine, along with haptic maintenance, which sends personnel to their respective platforms much better prepared for their role as maintainers. WR21 maintainers were being sent to their platforms without even having seen a WR21, and lacking confidence in a high pressure operational environment.

A common criticism has also been the lack of an accompanying course docket, as the original intention was to be able to access the synthetic courseware on board via the DLP. This proved to be not possible with lack of bandwidth provided to the ship, so the information provided on course was not easily referenced by ship's staff.

**WHAT COULD BE DONE?**

Whilst bearing all these points in mind, I was tasked with enhancing the WR21 training, due to the experience I had gained as M1G part of ship on board HMS Dauntless.

The first issue to address was the lack of haptic experience within the course. A non-running WR21 was available in Watt Hangar, HMS Sultan. This engine (designated B6) is the original manufactured WR21, and was used for the entire development programme, executed at Pyestock. The engine was manufactured and installed in a module designed to meet the original USN requirements, which presented considerable space constraints, and impractical working conditions for a sea going vessel. For the Type 45 application, the module was re-designed to be much larger in size.

Small changes had already been made to the engine, prior to its installation in Sultan. B6 came with no Recuperator or ducting, so the RAM and DAM were open for inspection, and the GRP Bellmouth was also now open to be seen from the front of the engine.

To best utilise B6 as a part task trainer (PTT), modifications needed to be made to the engine. The module walls were removed from the aft end of the engine (270kg

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*Engine B6, configured as a part task trainer*

each panel), to allow better visual inspection of the unique design of the exhaust system and multi-stage power turbine, as this is something not often seen on board, and is critical to correct operation of the Recuperator. Access to the T5 (PT Exit) sensors was also granted whilst removal of the High Speed Coupling Shaft Tunnel hatch and installation of lighting also added training value.

Removal of other small mechanical parts of the engine were also necessary ie PT flow guide, VAN, I/C wash nozzles and combustion equipment. This process was hindered, particularly where the combustion system was concerned, as Sultan lacked the ASE tooling to remove certain parts ie Discharge nozzles. ASE tooling has now been sourced to help with future removals, where maintainers will be able to carry out the task on computer, before then doing it for real on the engine.

Power sockets were also run to either side of the engine to allow for borescope inspections of the internal engine components. A borescope was made available by BAE Systems as a training aid, but remains a Fleet ready spare. The benefits of these additions, modifications and tooling will allow students to carry out maintenance tasks in a non-pressure environment, where mistakes can be made without potentially affecting the readiness of an operational ship. Numbers of WR21 within the Fleet are limited, so this is of huge benefit.

Large displays of media from the synthetic courseware also had to be designed, to be presented with the static trainer (bearing in mind International Traffic in Arms Regulations (ITAR) restrictions, for which a caveat from IPT had to be sought to only display certain aspects of WR21 and not to display sensitive information). Small labelling of engine components was also necessary as the complex cycle engine layout was very different to existing engines.

The largest modification to B6 was removal of the Accessory Drive Gearbox. This presented massive problems due to the space constraints and positioning of the gearbox and its weight (approx 260kg). The off-engine fuel system had to be removed from within the module, along with the driven pumps (fuel and oil) and the air start motor (Type 45 is fitted with hydraulic start), to get to the gearbox itself. Disconnection of the gearbox from the supports and bevel drive to HPC were very difficult, and required some creative engineering simply due to the space being worked in. Working upside down became the norm during the removal. Once disconnected, slinging of the gearbox ended up being a massive undertaking. The layout of the module required carefully applied brute force to get the gearbox out and away from the engine.

The gearbox is now to be used as a stand-alone PTT, and I have designed a frame to carry it for students to work on the gearbox itself, as well as to remove and replace the fuel and lub oil pumps. The off-engine fuel system will also be mounted as a PTT. This will allow for the students to dismantle and inspect the inner workings of each component.

I have also devised a five year plan for the further development of the WR21 PTT, to incorporate possible moving of the engine to Raper Block at Sultan, and further enhancements which include cutting of engine casings, RAM and Intercooler casing to display component internals, along with other large additions including models of key components (Recuperator etc).

The next major issue to consider was the lack of a supporting docket for the ME292D. Production of this was from the ground up and took much liaising with internal and external authorities to complete. The finished docket took five months to produce and utilised many pieces of media from the Technology Based Training Unit to further enforce the synthetic based information. Due to ITAR restrictions that are currently in place on the WR21, the docket will be closely controlled within Sultan and signed in and out by maintainers at the beginning and end of each course. The docket constituted the bulk of the overall workload during the WR21 project, but presents clear and concise information to aid new and existing maintainers to understand this leap forward in technology, including everything from construction to controls to ancillaries and all other engine components.

**THE RESULT**

The further development of WR21 training has been a very large undertaking, but benefit has already been seen by students coming through Sultan, as they can get hands on with a non-running engine, which is quite simply better than nothing. The intention is for the initial work is to be a springboard to gain further support and funding to the training package for the WR21 GT, and possibly be used as an example of what can be achieved with the limited resources that I was able to exploit and had at my disposal.

For my work on the WR21 GT training package, I received a HMS Sultan Commanding Officer’s Commendation in Summer 2012, followed shortly afterwards by a Herbert Lott Award for efficiency.

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# (ENGINEERING) EXPERIENCE IN RESERVE

## THE ROYAL NAVAL RESERVE AIR BRANCH

### By Commander Gary Duffield BSc MSc CEng MRAeS RNR
### RNR Air Branch SO1 AE


Gary Duffield joined the RN in 1972 as an Artificer Apprentice. He specialized as an Electrical Artificer (Air) and carried out Field Training on 707 Squadron (Wessex Mk 5). After being selected as an Upper Yardman he entered BRNC in 1977 and went on to complete a three year Naval Engineering Degree at RNEC Manadon. Graduating in 1981, he qualified as an Air Engineer Officer before becoming DAEO of 820 Squadron (Sea King Mk 5). He was then appointed to Cranfield Institute of Technology, where he gained an MSc in Computing Systems before being appointed as Avionics Officer to the RN Helicopter Special Maintenance Party at Westland Helicopters. He returned to RNEC as a lecturer before being appointed to 801 Squadron (Sea Harrier FRS1) as AEO. After serving as Fixed Wing Manager to Flag Officer Naval Aviation, his final appointment in the RN was as Sea Harrier Fleet Engineering Manager within DGA(N).

Gary left the RN in 1999 and immediately joined the RNR Air Branch; as a civilian he worked as a Further Education lecturer before joining Westland Helicopters as part of the Customer Support organization. During 11 years of civilian employment he achieved his annual training commitment for the RNR, initially as assistant to the Senior Support Engineer at RNAS Yeovilton where he undertook a variety of minor projects. He left Westland Helicopters in 2010. In 2006 he was promoted to Commander and appointed as SO1(AE) for the RNR Air Branch, where he continues to provide specialist support to the FAA.

**INTRODUCTION**

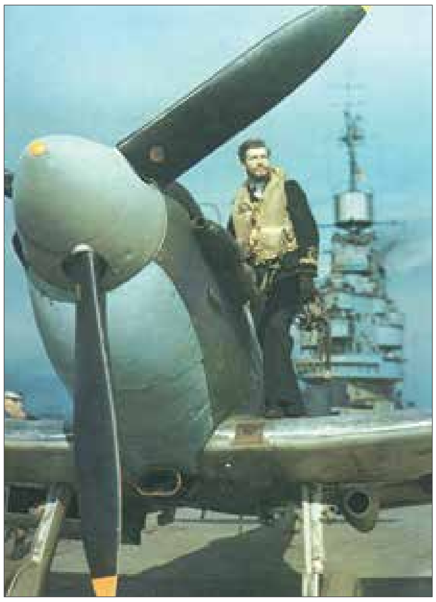
The Maritime Reserve consists of 2800 trained Royal Naval Reserve and Royal Marines Reserve personnel who are attached to 19 units across the UK and trained in specialisations including Logistics, Seaman (Above Water Force Protection), Amphibious Warfare, Media Operations, Medical, Maritime Trade Operations and Intelligence. Personnel progress their careers as part-time members of the Naval Service with periodic periods of mobilisation . The Air Branch is an integral part of the Maritime Reserve but functionally works for Rear Admiral FAA, formed entirely of ex-regulars who volunteer to utilize their experience and skills gained during regular service to continue to support the FAA on a part-time basis once their regular service has finished. All branches and trades of the FAA are represented with personnel embedded into squadrons and units where they contribute to the output of that unit. Attendance at the individual's unit is by mutual agreement with the unit and is fitted around their civilian employment. All members are liable for recall to service under the Reserve Forces Act 1996 (RFA96).

Since formation 33 years ago, the Air Branch has adapted and evolved to reflect the changing requirements of the FAA, most recently to the regulation changes resulting from the formation of the Military Aviation Authority. The Future Reserves 2020 (FR20) program adopted by the MOD plans to double the size of the UK Reserve Forces by 2020; the RNR Air Branch is already preparing to meet the challenges this will impose. Air Engineer (AE) and Survival Equipment (SE) personnel make up approximately one-third of the RNR Air Branch and like the other specializations in the Branch they pride themselves on being able to provide the FAA with "*Experience in Reserve*".

'*I couldn't possibly employ a part-timer! They would never be here. What about their currency? They wouldn't be safe. I would have a big training burden and get nothing back ...*' These are just some of the views that may be expressed about Reservists. However, just have a look at any of your experienced team members or colleagues who are about to leave the RN after many years of service and who have had a considerable amount of time, money and effort invested in their training. Then ask yourself this: '*Could I use that person's skills and experience for three or four weeks a year?*' The Fleet Air Arm believes that the answer to this question is '*Yes*'; if you want to see why, then read on.

**MARITIME AVIATION RESERVE HISTORY**

The Royal Naval Volunteer Reserve Air Branch (RNVR(A)) formed in 1938, recruiting civilians to train as aircrew flying the increasing number



*The heritage – an RNVR(A) pilot in the Second World War*

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of aircraft that were entering service with the RN; from 1939 all aircrew entering Naval service were RNVR(A). By the end of the war, numbers had increased to 46,000; this included aircrew and support personnel including engineers. The Branch was rapidly run down after the Second World War and ceased to exist by the end of 1945. Created again in 1946, the Branch recruited former wartime aircrew, and at its peak operated 12 squadrons of aircraft – but was disbanded along with RAFVR Squadrons in the 1956 defence cuts.

In 1980 the RNR Air Branch formed as an all-Officer structure with 33 aircrew officers who had recently left the RN. Liable for recall to service, they attended an annual two-week ‘training camp’ at an Air Station to refresh their perishable aircrew skills and then returned to their civilian jobs for the rest of the year. The idea was that if recalled to service during the Cold War period, their ‘flash-to-bang’ time would be relatively short. The Branch grew slowly and it took 10 years before the size increased to 80. In 1994, under Flag Officer Naval Aviation (FONA), the Branch opened its doors to all FAA ranks, rates and specializations: it was at this point that the first AE Ratings became part of the Branch. The Branch continued to grow, peaking at 431 in 2003.

The reservist used to be identifiable by the ‘R’ in the executive curl of officer’s rank lace and the ‘Royal Naval Reserve’ shoulder-flash worn by ratings on Number 1 uniform. These were both removed in 2005 and are now only worn by honorary RNR officers and URNU undergraduates who are non-deployable.

## THE RNR AIR BRANCH TODAY

The current Requirement for the RNR Air Branch is 320, with every specialisation of the FAA represented. With approximately 100 aircrew, 100 AE/SE personnel and 100 operational support personnel. The officer/rating split is about 50/50 across the Branch although in the AE/SE area this is a 5/95 split in favour of ratings.

Unlike the mainstream RNR units which parade as formed units on a weekly basis and carry out training programmes in preparation for periods of mobilisation, Air Branch personnel are each assigned to a FAA unit. The majority of these units are at RNAS Yeovilton, RNAS Culdrose and the Commando Helicopter Force which is part of Joint Helicopter Command, such as:

- Squadrons.
- Force Headquarters.
- Air Engineering Departments.
- Air Departments.
- Meteorology Departments.
- Survival Equipment Sections.
- Engineering Training Schools.
- Second-line workshops.
- Simulators.
- Air Traffic Control.
- RN School of Fighter Control.
- Fire Stations.
- Photographic Sections.

The remainder of the Branch is spread thinly across the UK in places such as:

- NCHQ.
- RNAESS at HMS Sultan.
- 1710 Squadron in Portsmouth Naval Base.
- Project Teams within DE&S.
- Air Experience Flights.
- FOST.
- Maritime Battle Staff.
- Defence Survival Training Organisation.

## PAY, BOUNTY & COMMITMENT

Air Branch personnel have an Annual Training Commitment (ATC) of 17 days per year and are subject to call-out for mobilized service.

*Serving with Squadrons*

Reservists are paid a daily rate of pay commensurate with their RNR rank/rate, this is lower than regular rates of pay as the x-factor is not paid to reservists. Specialist pay is paid where appropriate. A Reservist completing ATC is entitled to a tax-free bounty payment at the end of the training year. Additional achievement over the 17 day commitment does not attract additional bounty.

## APPLICATION AND JOINING

All Air Branch reserves are ex-regular, primarily RN or RM personnel recruited within three years of leaving full time service to form a pool of “*Experience in Reserve*”. All join in their substantive rank up to Lieutenant Commander or CPO, occasionally WO; they are selected for their particular specialist Service skills, experience and personal qualities. The philosophy is the retention of existing skills rather than teaching new ones, though opportunities for retraining can occur to suit operational requirements.

Applications to join the Branch are accepted from between 12 months before Tx date and up to three years after leaving full-time service. Selection and retention is competitive – Aircraft Force Commanders, Air Station Cdr (Air), Cdr (AE) and Squadron CO are consulted before an application is accepted or rejected.

Recent patterns of retention of regulars to age 45 and 50 have encouraged significant over-age recruiting and the average age of the Branch is about 48. Most applicants are senior ratings or officers who have completed a significant number of years’ service and wish to retain contact with the RN. Historically less than 5% of applications are from junior ratings.

Applicants who apply before in advance of their Tx date can be seamlessly transferred from the RN to the RNR subject to a medical which is usually carried out at the same time as their RN leaving medical; personnel who have left the RN before applying have to apply

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through their local Armed Forces Careers Office, a process which can take several months to complete.

An annual review of personnel enables early identification of areas where individuals are no longer of value and appropriate re-deployment action to be considered. The review also approves extensions of Service.

Normal Air Branch retirement age is 45 for aircrew and 50 for all others; however Service requirements favour extensions well beyond these norms.

## EMPLOYMENT OF RESERVES WITHIN THE FAA

While the aim of the Air Branch – to support the FAA in time of stretch, tension, crisis and war – has not changed since formation in 1980, the modus operandi has evolved from a once-a–year refresher period for aircrew to the current model which provides manpower year-round in small, medium and large chunks. The ethos of 'Experience in Reserve' however, remains the same; the Air Branch has been providing Suitably Qualified and Experienced Personnel (SQEP) since 1980.

Once accepted into the Branch, personnel are assigned to their employing unit and they are then responsible for liaising with that unit to agree a suitable pattern of employment. Additional days over and above the notional '17 days' may be available if the budget allows, the unit has a requirement and the reservist is willing and able to carry them out. Some reservists are able to complete their attendance in a single block whilst the majority will attend their unit for a number of shorter periods throughout the year.

Specialisations such as flying and air traffic control have clearly defined numerical criteria for maintaining currency and personnel arrange their attendance at their unit to maintain an acceptable level of currency. It can take a considerable amount of time and effort to regain currency once it is lost and this may not be possible with the restrictions imposed by having a day-job.

Most aircrew aim to retain flying currency in line with the current regulations and fly as instructors or other flying tasks Some are employed in non-flying areas such as duty officers, briefing officers, simulator instructors and others maintain currency operating similar aircraft in their civilian job. Aircrew have also been extensively used in the development of the Wildcat which will enter service next year to replace the Lynx. As well as developing and trialling the cockpit man-machine-interface they have validated training courseware prior to use. They have also validated the emergency egress drills, pre-flight walk-round checks and various other drills when wearing the existing and the new standard of flying clothing and safety equipment which has allowed the necessary 'clearances' to be achieved for the release-to-service documentation to be issued. When the first aircraft enters service Reservists will carry out operational analysis activities on the data that is generated.

*Wildcat in flight*

Air traffic control officers employed in the ATC organisations at Culdrose, Yeovilton and FOST ensure that they are suitably programmed into the watch-bill to maintain currency and continue to be of value to the RN.

Air Engineering and Survival Equipment personnel are integrated into squadrons, units and workshops where their skills and experience are put to use by the unit management team. Regulations regarding authorisations and competences are the same as for regulars and, for example, all aircraft maintenance supervisors must pass the annual Supervisor's Competency Check. Maintaining familiarity with a myriad of ever-changing technical instructions is perhaps the most challenging task for a part-timer and units have mechanisms in place to ensure that reservists as well as regulars maintain an appropriate level of awareness. Personnel whose day jobs are with defence contractors such as AgustaWestland, Serco or QinetiQ tend to have few problems where currency is concerned. Some AE and SE personnel are employed in off-aircraft roles where their experience is used in QA audits, instruction of junior personnel, manpower control duties and a range of other support activities that are essential to the running of a squadron or unit.

The RN can often benefit from the skills and experience that the reservist brings from a civilian job; without breaching any commercial confidences there are many areas where direct experience of systems, processes and procedures can allow the RN to gain a better understanding and appreciation. The Air Branch has two fixed-wing pilots who have already flown the F-35; they can use this experience to inform the discussion on the shape of the future training and operational activities. Examples are not restricted to the defence industry and qualifications in areas such as crew resource management, human factors and quality management systems can be utilised to good effect in the military environment. Industry is much quicker to adopt new ideas on management systems and support systems, where many reservists have experience of these long before their uniformed counterparts.

## MANAGEMENT OF THE AIR BRANCH

The Branch is commanded by a Commander RNR who is appointed as Head of the Air Branch (HAB) for a two year period, he is assisted by five specialist RNR SO1s with the following areas of responsibility:

- RNAS Culdrose
- RNAS Yeovilton
- Commando Helicopter Force

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- Operational Support (responsible for Op Support issues across all locations)
- Air Engineering (responsible for AE & SE issues across all locations)

The Executive Senior Rate (ExSR) of the Air Branch is a CPO or Warrant Officer who acts as a focal point for all issues concerning senior and junior ratings. This position is held for two to three years and is open to competition from personnel who are able to commit more than 17 days annually and are willing and able to cover all Air Branch locations on a regular basis. The SO1s and ExSR attract 'additional days' over and above the standard 17 days to enable them to carry out their duties.

A Permanent Staff of one full-time retired officer in a Military Support Function (MSF) post, three civil servants and one RN Leading Writer based at RNAS Yeovilton and RNAS Culdrose provide day to day administration with responsibility to HAB for such as management of attendance, support to the FAA, recruiting, career management and Employer Liaison. Staff Officer Reserves, on ACNS (Aviation & Carriers) staff, provides the strategic impetus and focus within the higher management of the FAA in NCHQ.

Management of the Branch continues to develop the best possible individual relationships between the RN unit and the RNR individual so as to have the Reservist in place supporting the unit when he/she is most needed – to relieve gapping, to ease stretch and to focus unique specialist skills and experience. The Air Branch is perhaps best described and understood as "Regulars who work part time".

**MOBILISED & FULL TIME RESERVE SERVICE**

Throughout the last 10 years over 12% of the Branch has been mobilised or on Full Time Reserve Service. Periods of compulsory mobilisation are for a maximum of 12 months and once a period is complete another compulsory period of service cannot occur for at least three years.

The largest amount and possibly the most effective support provided to the FAA is by personnel who attend their unit on a part-time basis during the working week. On any given day there are between 10 and 20 individuals working in support of the FAA. There are standing Ad Hoc recall arrangements with several units with gapped billets and available funding to enable the Reserve to plug a gap as and when available at short notice.

**CIVILIAN EMPLOYERS**

The majority of Reservists are employed by civilian companies and the Maritime Reserve and the Air Branch maintain close links with them where possible. The major employers for Air Branch Engineers are the Civil Service, AgustaWestland, Serco and Qinetiq. The civilian employer often gives additional leave to allow Reserve Forces activities to be undertaken, the exact number of days vary between companies. The Company benefits by having a motivated employee who continues to exercise the skills and increase the experience that they saw when they recruited the individual. The RFA96 ensures that an individual's job must remain open after a period of compulsory recall-to-service.

**FUN FACTOR**

RNR personnel continue to have access to a range of sporting, social and general activities that were open to them as regulars. Some of these activities are 'unpaid duty' and the fun-factor attracts personnel to give up their time to participate in these events. Some of these activities attract a daily rate of pay although this will only be paid once their 17 day commitment has been achieved at their employing unit. A number of Air Branch personnel attend the RNWSA championships each year, the RNR sailing regatta, and the RNRM Skill at Arms meeting at Bisley. Other activities supported by Air Branch personnel include Brickwoods Field Gun as part of the Maritime Reserve team, the AELTC championships at Wimbledon and the Mountbatten Festival of Music as stewards. Personnel also volunteered to take part in the Armed Forces Jubilee Muster at Windsor, the Thames River Pageant, Falklands 30th commemoration, and to act as members of the Venue Security Force at Op Olympics. It might seem strange to give up your spare time to attend a parade but there is never a shortage of volunteers for activities such as these.


*Supporting the unit – 771 NAS*

**THE FUTURE**

The implementation of FR20 will result in an increase in the number of Maritime Reserve positions and a greater integration with the regulars. Initiatives such as the New Employment Model and more flexible career patterns could allow someone to ease out of mainstream RN and spend some time in the Reserve before rejoining the RN. Such a route would undoubtedly have implications on career prospects but it would allow skills to be retained in a time when the RN is competing with the private sector to attract and retain the right calibre of people. This is particularly relevant to the Engineering specialisation.

Whatever the future brings, the contribution that has already been made by the men and women of the RNR Air Branch has been considerable and they will undoubtedly continue to give up their spare time to use their skills and experience for the benefit of the Fleet Air Arm.

**WANT TO KNOW MORE?**
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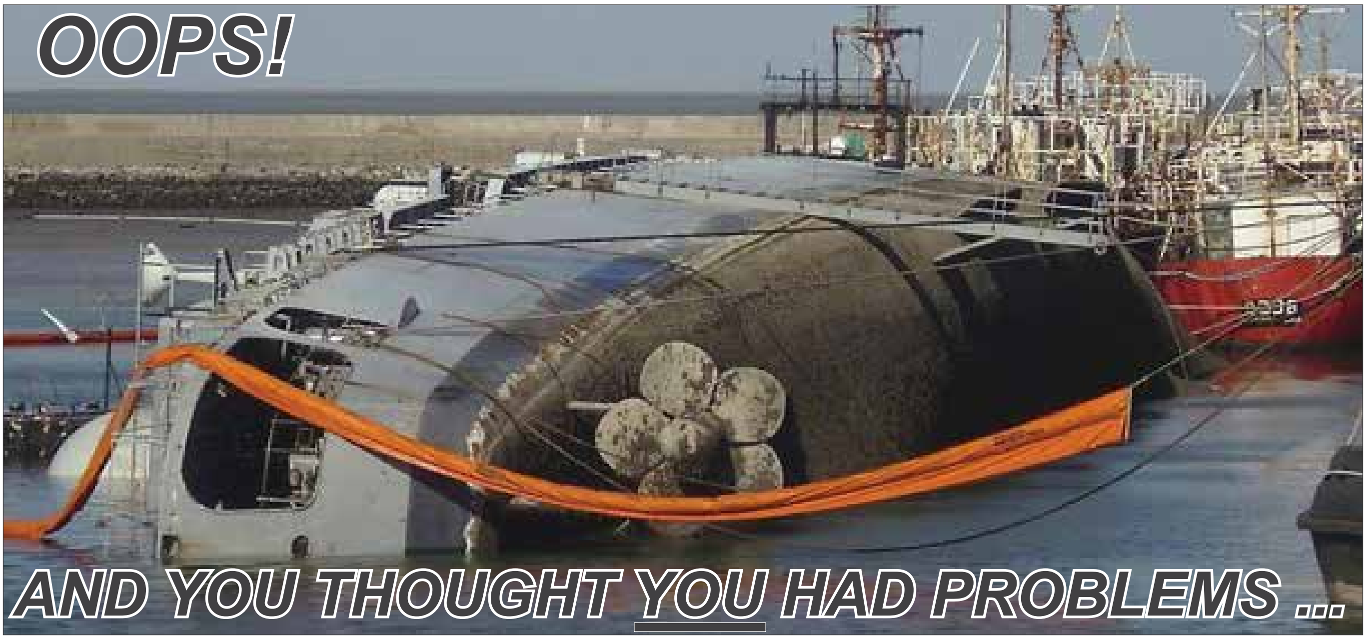
# OOPS!



## AND YOU THOUGHT YOU HAD PROBLEMS ...

These photographs, taken from the Internet, show the Argentine Type 42 destroyer ARA Santisima Trinidad, which capsized and sank on 21 January 2013 at her berth at Puerto Belgrano (Argentina's main naval base).

According to Internet accounts, an underwater valve failed, the ship took on lots of water and quickly sank, despite efforts by her skeleton crew to save her.

She was built under license by AFE, the Argentine shipyard in Buenos Aires, spent some time in the UK undergoing trials and set-to-work and had taken a major part in the early phases of the Falklands Conflict, acting as the command ship for the naval and army commanders of the Argentine invasion force and landing special forces at Mullet Cove to attack the Royal Marines barracks at Moody Brook. Of late, however, she has lain idle for some years at Puerto Belgrano, largely as a spares source for her sister ship, ARA Hercules and awaiting disposal.

This is not the first time this particular ship has been involved in unfortunate incidents. Before completion, she was alongside in the shipyard in 1975 when she was sabotaged by guerrilla forces, who laid a limpet mine on the river bed under her hull; damage caused by its detonation delayed her completion by about a year. In May 1982 her embarked helicopter collided with the ship and was lost overboard, killing the aircrew.

The Argentines have stated that they will refloat the ship. Whether this takes place remains to be seen, and whether the results of any investigation are made public is also unclear – your editor will watch out for any further information.

Could your duty watch deal with a major water ingress like this? Are there systems and processes in place to give warning of such an event?

*The Editor*

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# TEN COMMANDMENTS[1] OF ELECTRICAL SAFETY

I. Beware of the lightning that lurketh in seemingly uncharged capacitors lest it cause thee to bounce upon thy buttocks in an unseamanlike manner and cause thy hair to stand on end, thereby exceeding regulation length.

II. Cause thou the switch that supplieth large quantities of juice to be opened and thusly tagged, that thy days may be long in this earthly vale.

III. Prove to thyself that all circuits that radiateth and upon which thou worketh are grounded and thusly tagged, lest they lift thee to radio frequency potential and causeth thee to radiate with the angels.

IV. Tarry thou not amongst those fools that engage in intentional shocks, for they are not long of this world and are surely unbelievers.

V. Take care thou useth the proper method when thou taketh the measure of high voltage so thou dost not incinerate both thee and thy test equipment. For verily, though thou hast no NSN and can be easily surveyed, the test equipment has one, and as a consequence, bringeth much woe to thy supply officer.

VI. Take care thou tamperest not with interlocks and safety devices, for this incurreth the wrath of thy department head and bringeth the fury of thy Commanding Officer on thy head.

VII. Work thou not on energized equipment without proper procedures, for if thou dost so, thy shipmates will surely be buying beers for thy widow and consoling her in ways not generally acceptable to thee.

VIII. Verily, verily, I say unto thee, never service equipment alone, for electrical cooking is a slow process, and thou might sizzle in thine own fat upon a hot circuit for hours on end before thy maker sees fit to end thy misery and drag thee into his fold.

IX. Trifle thee not with radioactive tubes and substances lest thou commence to glow in the dark like a lightning bug and thy wife be frustrated and have no further use for thee except thy wages.

X. Commit thou to memory all the words of the prophets which are written down in the 300th chapter of thy bible which is the 'Naval Ship's Technical Manual' and giveth out with the straight dope and counseleth thee when thou hast suffered a ream job by thy division Chief.

1. Taken from an old US Navy publication, this was clearly written for a male audience, but its message is equally relevant today to readers of either gender.!