Defence SA Submarine Design and Engineering Course

SPEECH BY ASC MANAGING DIRECTOR AND CHIEF EXECUTIVE OFFICER STEVE LUDLAM

21 July 2010

Thank you for your kind introduction Andrew and for inviting me to speak tonight.

I would also like to acknowledge Air Vice Marshall Chris Deeble and Commodore Bronko Ogrizek of the Defence Materiel Organisation, as well as Mr Rod Equid, the Chief Executive Officer of the Air Warfare Destroyer Alliance. Your support here tonight is most appreciated.

I also offer a big welcome to the students of the submarine design course and hope that you can benefit from the discussions over dinner this evening.

Looking around, I can see that I haven't met many of you, so I can only imagine what you must be thinking… "Who is this bloke?"

Let me begin by properly introducing myself.

I am an engineer recently elected as a Fellow of the Royal Academy of Engineering in the United Kingdom. I commenced my career as a mechanical engineer then qualified as a nuclear engineer.

Throughout my entire 35 years of working life, I have been involved with submarines and ships - in the UK, Europe and the United States.

I was delighted to join ASC earlier this year after many years spent with Rolls Royce.

Given that this dinner is a part of the submarine design course, I would like to devote this speech to sharing my thoughts with you on the impact engineering has on submarine design.

The truth is… We either get it right or we get it wrong!

This would make quite an interesting topic for a thesis or an essay.

When we get it right everything works perfectly and, obviously, when we get it wrong it doesn't. Don't we all wish life was as black and white?

Our job is to produce a series of design options, analyse them and then reduce the number of choices. We undertake some more research and development, and further reduce our choices, until eventually; we detail one design, make it, operate it and then maintain it.

We may have optimised the design on performance or cost (or tried to do both). If we did optimise on cost we probably tried to balance it between initial cost and through-life cost.

So here is the first key point I would like to make – **we never get our optimisation right**.

The envelope of optimisation is huge and it has many parameters in conflict with one another. We never know the full relationship between the parameters until we pick one at a time to optimise.

In fact, it is virtually impossible to understand the full relationship between parameters, so what we are really doing is deciding what we believe we know about, and believe that in the optimisation we can interpolate or extrapolate, to a point of certainty and hence provide ourselves with a clear design.

So, even though in the space we believe we know about we actually don't know everything.

The second key point I would like to make then is – **learn to manage uncertainty**.

You must learn to manage ambiguity and learn to be clear about what you really do know. Collate the evidence to support your view and then have the foresight to identify the gaps in your knowledge. In other words, we must manage the risk of uncertainty.

So let's take a look at these first two points in the context of my own personal experience. Believe me; I have fallen foul of both of these points a number of times.

Firstly, optimisation: I recall a particularly high profile and politically embarrassing example which resulted in a UK submarine being stranded in Gibraltar, the island at the entry to the Mediterranean, for over a year.

The thermodynamic and fluid mechanics of a high pressure, high temperature fluid system used the pressure driving head to function in a passive manner. By passive, I mean in a 'non-moving parts' manner. The elevation, bends and fittings were all optimised to provide the pressure driving head over the necessary range of temperature and fluid states.

During a standard exercise, however, the connection between this system and another system failed, leak before break, and the submarine became stranded.

We knew that we had used standard calculations; we knew that our simple whole-system mathematical model was validated; and we knew the material performance over this range of conditions. Therefore, we knew that the leak was caused by a stress raiser resulting from poor manufacture. And, as a result, we knew our optimisation plan had been incomplete - we should have had a third optimisation parameter on manufacturing quality or geometry.

Let me now introduce the second part on managing the risk of uncertainty.

The reality was we assumed a standard approach would work but the devil was in the detail. We should have undertaken a detailed 3D stress model and 3D fluid flow model which would have revealed the real driver of the crack - a complex eddy that was actually thermally cycling a high stress area.

As it turned out, we really didn't know what we thought we knew.

What this experience highlights is the importance of obtaining as much knowledge as you can through experience, training, R&D and S&T, by assembling a multi-disciplinary team that talks together constantly, shares information, continually checks the accuracy of information and constantly tests assumptions.

I cannot stress how important knowledge generation is for complex naval platforms like submarines, where design decisions (like my previous example demonstrates) are made every hour of every day.

The interfaces and the interrelations need to be worked constantly; always accurately checking that a decision taken in one part of the submarine doesn't affect another part – the concept of a systems integrator is one to remember.

The importance of obtaining as much knowledge as possible becomes especially important when we consider the area of technology development…

The submarine world has been, and will continue to be, a breeding ground for technology.

The first submarines were built 100 years ago at the beginning of the last century. With innovations such as steam power, the UK K Class was designed to keep up with the fleet.

The UK M Class, with a huge gun in one and an aircraft hangar in another, both somewhat missing the point about what a submarine is best at but equally explaining the enormity of design challenges these submarines presented – both ostensibly the same class but both very different submarines by virtue of their different missions.

Moving on to the success of the German U Boats in World War II, and the long range Pacific submarines (not unlike the demands placed on Collins Class), to the nuclear submarine and to air independent propulsion systems and ultimately UUVs in the extreme.

With combat system requirements expanding on an exponential scale, and detection and counter-measure systems constantly improving, weapons are becoming even more effective in the sea, with submarine weaponry now more effective at sea and in land attack.

Perhaps the biggest examples of technology changes over the last 100 years include nuclear propulsion, air independent propulsion, combat systems, sonar, signal strength reduction, atmosphere control and hull shape.

Each change has been researched and developed carefully before being committed to a submarine design. Each evolutionary change has been improved considerably through in-service feedback, with each change proving to deliver tactical significance before being incorporated.

In addition, each change has been led by a capable and dedicated team of engineers researching and developing it.

So is an air independent propulsion submarine better than a nuclear submarine?

This is another good question for an essay.

Each has experienced a long period of development before deployment, and each has experienced considerable development from in-service feedback - remembering my earlier point with regard to managing uncertainty.

Depending on the AIP system, the submarine design has required considerable change particularly in boat through systems, and AIP systems fuel and oxygen storage. While the nuclear submarine led the way in new hull forms and set new challenges for atmosphere control.

A submarine is one of the most complex engineering systems man has ever made and can be likened in complexity to a space shuttle. So as designers, manufacturers and operators, we must manage the risk of uncertainty every day and protect the lives of those who serve on them.

In that sense our equation becomes important – what I call the Submarine Equation: the number of dives divided by the number of surfaces must always be equal to 1.0. This must be a certainty.

So the way we work together as a team must be one of effectiveness and efficiency, with as complete an understanding as we can get of the whole submarine system before and during its service life – the role of the systems integrator.

Let me now turn to a different and perhaps controversial topic. I now move from the world of design into the world of design choices.

Should we choose a military off the shelf solution or design our own submarine here in Australia? Reinforcing my earlier point once again, we need to be sure of what we really know and what we don't know.

The requirements for Australia's future submarine need to be crystal clear. These requirements are predicated by military threats and they span the range required, the seas to be patrolled, the military capability needed and the growth margins necessary to stand a chance of coping with changing military threats.

There are some givens: value for money which inevitably will translate into the lowest procurement cost for maximum military capability, the lowest through-life support cost, maximum sailor comfort and absolute safety of operation.

Competition for Australia's future submarine is a necessity. First of all, a competition is required between designs to ensure innovation, efficiency and demonstrable value for money.

The military off the shelf designs to be considered may be French, German, Spanish, or the Collins Class herself. And, for a design to be classified as a 'MOTs design', the submarine must be at sea today.

Design modifications will be necessary for all MOTs designs to meet Australian requirements, including Australian legislation and to suit the areas Australia patrols.

The complexity of the mission and a 30-year operating life must also be factored in.

A growth margin needs to exist in order to cope with changing military strategies, tactics and new technologies. The use of submarine borne mines, unmanned underwater vehicles and submarine launched unmanned airborne vehicles are just a few roles that Australia's next submarine might need to perform in the future.

My theme of managing uncertainty I hope demonstrates that there is no such thing as a perfect design which never fails in service.

So our ambition for the new submarine must be met by an indigenous Australian capability to support the chosen submarine through-life. There is nothing more certain that complex machines fail on occasion and, if you haven't got your own capability to fix them, then your military capabilities are weakened.

Your own capability to fix them starts with your own capability to understand the design and this is best achieved by being part of the design – by being the systems integrator - the design authority.

So I will conclude with a few thoughts about Australia's place in the future of submarine design.

Australia needs her own capability to design, manufacture and support through-life the Royal Australian Navy's submarines.

We need to be competitive on a world stage to demonstrate value for money. We need to have confidence on the back of what is truly an impressive performance with Collins to believe we can do it. We need a few brave leaders here in Australia to make it happen and let the country truly understand why we need it and how capable we are. We need to engage with small to medium enterprises to facilitate their innovation and skills to produce value for money.

In every sense we need to continue to build our national capability for ship building and submarine building, and we need to have an exemplary performance in our management of uncertainty.

Those of you here from the submarine design course have a remarkable future in front of you if, together, we work hard with innovation and dedication.

The future Australian submarine should have a large Australian content and be a focus for a competitive ship and submarine building capability here in Australia.

I will finish with the only partisan comment I will make, and it is based on my short time here in Australia; short but welcoming.

It was immediately apparent to me the moment I arrived in Adelaide that the shipbuilding and submarine skills here are second to none and, with strong leadership, they will be world beating.

The South Australian Government has been brave, determined and should be commended for its huge foresight. South Australia deserves to be the home and heart of Australia's national shipbuilding and submarine capability. Together, we will have to prove that we deserve it we will need to be competitive on a world stage and, in the end, I believe that South Australia will prevail.

Thank you for inviting me to speak tonight. I will be happy to answer some questions.