Technology Insertion - A Marine Engineering Perspective

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Abstract
Technology Insertion (TI) can be defined as the process of incorporating and exploiting new or improved technology into existing platforms, systems and equipment (Reference 1). A similar term that is used in the US is technology refreshment. Technology refreshment is defined by the US Department of Defence as the "The periodic replacement of commercial off-the-shelf (COTS) components within larger systems to assure continued supportability of the system through an indefinite service life" (Reference 2). In the context of this paper both instances will be classed as TI as the activities to manage and apply both terms are considered the same.

The requirement for effective TI management is being increasingly acknowledged by navies throughout the world. For example, platform design life aspirations and environmental legislature requirements are increasing along with the frequency of combat system enhancements. The need to pro-actively manage obsolescence, in most situations, is also accepted so against these requirements the need for cost effective TI planning through life is recognised as being an essential, and not necessarily a trivial problem to solve. Accurate prediction and justification at the platform design stage of the likely technologies that will require introduction later in platform life is challenging. Therefore, one requirement for the effective management of TI is a need to design flexible and easily adaptable platform systems (e.g. hydraulics, Low Pressure (LP) and High Pressure (HP) Air, Heating Ventilation and Air Conditioning (HVAC) systems and electrical power generation and distribution).

This paper begins by further exploring the reasons behind TI, focusing largely on the marine engineering and design aspects of naval submarine platform systems to support evolutionary acquisition and TI. Potential enablers for platform systems TI in this context are discussed and evaluated. The paper concludes by discussing a number of platform system design improvements, themes and tools that have the potential to better embrace TI through life.

Nomenclature

AIP  Air Independent Propulsion
A&A  Alteration and Addition
CCD  Closed Cycle Diesel
CLS  Contractor Logistic Support
COTS  Commercial off the Shelf
DStan Defence Standard
HVAC Heating Ventilation Air Conditioning
LET  Logistic Escape Trunk
Li-ion Lithium Ion
PEM  Proton Exchange Membrane
PMS  Platform Management System
SF   Special Forces
SSBN Ship Submersible Ballistic Nuclear
SSGN Ship Submersible Guided Missile
SSN  Ship Submersible Nuclear
TDP  Technology Development Programme
TI   Technology Insertion
TMAP Technology Management and Acquisition Planning
UPC  Unit Procurement Cost
ZEBRA Zero Emission Battery Research Activity

1. Introduction

1.1. Overview
The concept of technology update and refresh focused on combat system equipment onboard a warship was introduced several years ago (Reference 3). The ability to replace or update such equipment at short notice and to increase the capability of the vessel through life is now a reasonably common practice.

1.2. The Need
The operational community require future submarine concepts that are affordable, adaptable and flexible. Consequently, there is an increasing drive to provide future submarine platforms with modular weapons to allow for ease of ship fit and potential reconfiguration. Leadmon et al (Reference 4) offers a useful explanation of the concept of payload modular submarines.

Submarine command, control and combat system equipment (i.e. sonar, weapons, communications etc) are increasingly designed with open systems architectures easing the process of software and hardware updates.
In the UK the recent publication of the Defence Industrial Strategy White Paper (Reference 5) makes the need clear with the statement:

“We need to develop design and acquisition processes to enable technology insertion through equipment life”

In addition, there is also an overarching expectation that vessel design life can be increased, due in part to postpone the significant costs of replacement.

Clearly these issues increase the importance of planning for TI through life. One of the biggest impacts on future platforms will be to design sustainable, maintainable and adaptable platform systems with increased growth margins that support practical evolutionary acquisition as much as possible.

1.3. Recent Examples

The integration of systems and equipments into future submarines is a challenge designers and engineers are stepping up to meet. One example is the US Navy’s VIRGINIA Class of submarine that has been designed with TI in mind and is ready to support modular payload concepts. Her designers envisage being able to implement evolutionary and revolutionary technologies at the component, system and equipment level as they become available (Reference 6).

![Figure 1 - Virginia Class SSN](Source - Official US Navy Website)

This need for increased platform life and role transfer is probably best demonstrated by the recent return to the US Fleet of USS OHIO during February 2006 (Reference 7). Four OHIO-class SSBNs that were previously scheduled for decommissioning during 2003 and 2004 continue to be converted to guided missile submarines (SSGNs).

![Figure 2 - Ohio Class SSGN](Source - Official US Navy Website)

The new primary roles of the OHIO class are land attack and Special Forces (SFs) insertion and support with a secondary role undertaking more traditional attack submarine missions.

1.4. The Need For Change

The culture changes demonstrated within the combat systems community also need to be fully embraced by the marine engineering community. Traditional submarine designs tend to be mission optimised platforms and the consequence is that they are not normally readily or easily adaptable when most navies’ resource constraints are considered.

Platform systems within UK nuclear submarines of the 70s, 80s and 90s have not been designed with flexibility and adaptability as a primary consideration.

The platform system contribution to the submarine role is largely as a service provider, providing electrical power, HVAC facilities and hydraulic power amongst other attributes. Propulsion and platform systems are sized at build based on specific performance requirements and tend to only incorporate modest margins for growth and unknown future needs. Such margins mean that existing platform systems can only provide for limited growth and change. As argued in the preceding paragraphs this will have to change for two principal reasons:

- To support combat system TI;
- To facilitate use of Commercial Off the Shelf (COTS) equipments throughout the vessel and manage obsolescence.

2. Technology Insertion Historical Review

In order to explore the extent of TI in the context of current classes of UK submarines a statistical review was undertaken to ascertain the spread and distribution of activities that could be attributed as TI for a particular class of UK SSN which has been in service for approximately 15 years.

All Alteration and Addition (A&A) activities associated with equipment or system upgrade
were reviewed. Those that could be classed as TI were identified and then categorised into a number of functional system groups (e.g. Sonar, Steam, HVAC, etc). They were then grouped into two key topic areas (i.e. combat or platform) as listed below at Table 1.

<table>
<thead>
<tr>
<th>Combat Topic Area</th>
<th>Platform Systems Topic Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>External Communications</td>
<td>Steam Systems</td>
</tr>
<tr>
<td>Sonar</td>
<td>Atmosphere Monitoring</td>
</tr>
<tr>
<td>Command and Control Systems</td>
<td>Trim, Bilge and Ballast</td>
</tr>
<tr>
<td>Weapons</td>
<td>Atmosphere Cleansing</td>
</tr>
<tr>
<td>Navigational Equipment</td>
<td>HVAC</td>
</tr>
<tr>
<td>Recording and Telemetry</td>
<td>Damage Control and Firefighting</td>
</tr>
<tr>
<td>Electronic Warfare</td>
<td>Condition Monitoring/Reporting</td>
</tr>
<tr>
<td>Internal Communications</td>
<td>Escape and Rescue</td>
</tr>
<tr>
<td>Periscopes</td>
<td>Feed Water Systems</td>
</tr>
<tr>
<td>Stabilisation &amp; Navigation Input Devices</td>
<td>Propulsion</td>
</tr>
<tr>
<td>Tube Launched and Handling Systems</td>
<td>Electrical Distribution</td>
</tr>
<tr>
<td>Unknown</td>
<td>Environmental Monitoring</td>
</tr>
<tr>
<td>Data Highway Systems</td>
<td>Fire Detection Systems</td>
</tr>
<tr>
<td>Surface and Air Warfare</td>
<td>High Pressure Air</td>
</tr>
<tr>
<td>Administration Services</td>
<td>Lubricating Oil Systems</td>
</tr>
<tr>
<td>Command and Support Systems</td>
<td>Sanitary Systems</td>
</tr>
<tr>
<td>Condition Monitoring/Reporting</td>
<td>Submarine Manoeuvring and Control</td>
</tr>
</tbody>
</table>

Table 1 - List of Key Topic Areas and Functional Groups

When each topic area was analysed further the results presented at Table 2 were revealed. For the combat systems topic area most activity was undertaken in external communications and sonar functional groups. These changes generally involve the upgrade of electronic racks and physically small equipment, but they do tend to have complex interfaces and often require additional powering and cooling provision.

<table>
<thead>
<tr>
<th>% Occurrence</th>
<th>Functional Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>External Communications</td>
</tr>
<tr>
<td>18</td>
<td>Sonar</td>
</tr>
<tr>
<td>8</td>
<td>Command and Control Systems</td>
</tr>
<tr>
<td>7</td>
<td>Weapons</td>
</tr>
<tr>
<td>7</td>
<td>Navigational Equipment</td>
</tr>
<tr>
<td>6</td>
<td>Recording and Telemetry</td>
</tr>
<tr>
<td>5</td>
<td>Electronic Warfare</td>
</tr>
<tr>
<td>4</td>
<td>Internal Communications</td>
</tr>
<tr>
<td>2</td>
<td>Periscopes</td>
</tr>
<tr>
<td>2</td>
<td>Stabilisation &amp; Navigation Input Devices</td>
</tr>
<tr>
<td>2</td>
<td>Tube Launched and Handling Systems</td>
</tr>
<tr>
<td>1</td>
<td>Unknown</td>
</tr>
<tr>
<td>1</td>
<td>Data Highway Systems</td>
</tr>
<tr>
<td>1</td>
<td>Surface and Air Warfare</td>
</tr>
<tr>
<td>1</td>
<td>Administration Services</td>
</tr>
<tr>
<td>1</td>
<td>Command and Support Systems</td>
</tr>
<tr>
<td>1</td>
<td>Condition Monitoring/Reporting</td>
</tr>
</tbody>
</table>

Table 2 - Frequency of Occurrence for Combat System Functional Groups

The results presented at Table 3 are focused on platform systems. The analysis revealed that most activity was undertaken in steam (i.e. propulsion), atmosphere monitoring & cleansing, trim, bilge & ballast, and HVAC systems.

<table>
<thead>
<tr>
<th>% Occurrence</th>
<th>Functional Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Steam Systems</td>
</tr>
<tr>
<td>11</td>
<td>Atmosphere Monitoring</td>
</tr>
<tr>
<td>11</td>
<td>Trim, Bilge and Ballast</td>
</tr>
<tr>
<td>9</td>
<td>Atmosphere Cleansing</td>
</tr>
<tr>
<td>9</td>
<td>HVAC</td>
</tr>
<tr>
<td>7</td>
<td>Damage Control and Firefighting</td>
</tr>
<tr>
<td>5</td>
<td>Condition Monitoring/Reporting</td>
</tr>
<tr>
<td>5</td>
<td>Escape and Rescue</td>
</tr>
<tr>
<td>5</td>
<td>Feed Water Systems</td>
</tr>
<tr>
<td>5</td>
<td>Propulsion</td>
</tr>
<tr>
<td>5</td>
<td>Vibration/Signature Reduction</td>
</tr>
<tr>
<td>3</td>
<td>Electrical Distribution</td>
</tr>
<tr>
<td>2</td>
<td>Environmental Monitoring</td>
</tr>
<tr>
<td>2</td>
<td>Fire Detection Systems</td>
</tr>
<tr>
<td>2</td>
<td>High Pressure Air</td>
</tr>
<tr>
<td>2</td>
<td>Lubricating Oil Systems</td>
</tr>
<tr>
<td>2</td>
<td>Sanitary Systems</td>
</tr>
<tr>
<td>2</td>
<td>Submarine Manoeuvring and Control</td>
</tr>
<tr>
<td>2</td>
<td>Domestic Systems</td>
</tr>
</tbody>
</table>

Table 3 - Frequency of Occurrence for Platform System Functional Groups

The main focus of the statistical survey was to determine the extent of TI in both combat system and platform areas. The results of the survey show approximately 73% focused on combat system changes with the remaining 27% distributed amongst platform systems.

An additional observation relates to the actual quantity of work undertaken and the physical time the platform is out of service carrying out this work. Because future platforms are likely to see an increased volume of TI activities it is essential to reappraise the overall design of vessels and truly design with TI in mind. Otherwise the elapsed time to upgrade each vessel in a class may not actually be available and vessels could spend more time out of service than is acceptable with significant disruption to their programmes.

3. Platform System Technology Insertion Drivers

3.1. Past Platform System TI Drivers

As the main focus of this paper is on platform system TI the TI drivers considered relevant to these systems will now be addressed.

A brief study was undertaken to identify the principal TI initiating requirements (i.e. drivers) for each activity detailed in the previous section for both combat and platform systems. The results are presented at Table 4 and Table 5 respectively. It is noted that a number of TI initiators can be attributed to a single activity but a principal initiator can generally be defined, be it obsolescence, capability improvement or availability/reliability shortfalls.
Table 4 - TI Initiators For Combat Systems Topic Area

<table>
<thead>
<tr>
<th>Area</th>
<th>% Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capability Improvement</td>
<td>73</td>
</tr>
<tr>
<td>Obsolescence</td>
<td>14</td>
</tr>
<tr>
<td>Trials</td>
<td>6</td>
</tr>
<tr>
<td>Safety</td>
<td>5</td>
</tr>
<tr>
<td>Unknown</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 5 - TI Initiators For Platform Systems Topic Area

Capability improvement was the most frequent initiator of change for both platform and combat systems. With respect to platform systems maintainability and reliability is a frequent TI initiator and a reasonable number of obsolescence, safety and escape related changes occurred. Only one change is related to legislation which is believed to relate to activities associated to cold and cool room refrigerant replacement.

### 3.2. Current and Future Platform System TI Drivers

With step changes affecting future submarines it is considered more important for the platform system to be able to adapt and support these changes. In addition, platform systems themselves are likely to be subject to more frequent technology insertion activities for a variety of reasons including the increased adoption of COTS solutions.

Taking the results of Tables 5 and 6, a selection of current and future TI drivers are defined at Table 6 with those which are more relevant to platform systems being identified explicitly.

Table 6 – Platform TI rankings

<table>
<thead>
<tr>
<th>Driver</th>
<th>Explanation</th>
<th>Relevance in Terms Of Platform Systems TI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance and/or capability</td>
<td>TI associated with improving performance or capability</td>
<td>High - Platform systems need to meet the needs of evolving combat systems</td>
</tr>
<tr>
<td>Obsolescence and support</td>
<td>TI associated with managing obsolescence</td>
<td>High - Effects both platform systems and combat systems. As platform life increases obsolescence issues are likely to increase</td>
</tr>
<tr>
<td>Regulatory environment</td>
<td>TI associated with meeting changing regulatory requirements such as safety and environmental aspects</td>
<td>High - It is in the interests of navies to meet MARPOL and other legislative requirements as far as reasonably practicable to allow for worldwide deployment</td>
</tr>
<tr>
<td>Technology refresh rates including COTS</td>
<td>TI associated with increasing technology refresh rates with the adoption of COTS equipment</td>
<td>High - Platform system equipment is subject to an increase in the adoption of COTS equipment</td>
</tr>
<tr>
<td>Availability, maintainability and reliability shortfalls</td>
<td>TI associated with controlling availability, maintainability and reliability shortfalls</td>
<td>Medium - There has always been a requirement to manage reliability and availability shortfalls</td>
</tr>
<tr>
<td>Technology demonstrators and trials</td>
<td>TI associated with running minor trials and demonstrations</td>
<td>Medium - There is likely to be an increase in the volume of equipment that will require trials prior to being introduced into an operational platform</td>
</tr>
</tbody>
</table>

4. Potential Platform System TI Enablers

4.1. Overview

A number of design improvements and themes that have the potential to make platform systems more TI receptive are explored below. In summary, such improvements include:

- Improvements in arrangement and outfitting;
- Increased adoption of modular and zonal platform systems design and build approach (i.e. discussed in more detail later);
4.2. Arrangement and Outfitting Aspects

Removal and installation of equipment in the confined space of the submarine can be extremely difficult. Improvements with respect to the arrangement of equipment, systems and pipework within the submarine at design and outfitting stages are considered essential and must be made in order to support future TI activities. Whilst improving accessibility is not considered a trivial problem to solve, improvements must be made to assist equipment installation and maintenance activities through life.

At a purely simplistic level one improvement could be to increase the size of the submarine. The drive to reduce the size of the pressure hull envelope in order to reduce acquisition costs is well understood. However, steel fabrication costs may be lower overall when compared to the prohibitive costs of outfitting, operator benefits, through life maintenance and TI later in life when constrained in a small platform.

Expanding this argument further, an extreme solution to this problem may be to change the traditional single cylinder hull design to a multi-hull configuration.

Other improvements may be made by allocating dedicated service routes for cables and fluid systems and rigidly respecting these routes during manufacture. This should reduce the time to install equipment taken through initial design, build and through life stages thus reducing costs in both build and through life maintenance and TI.

Accurate and defined installation and removal routes for equipment are considered extremely helpful. Recent US and UK submarine designs utilize a number of LTEs (Logistic Escape Trunks) that provide a hole of approximately 0.7m in diameter that can be increased to approximately 1.8m with the LET fully extracted to allow transits of equipments into and out of the submarine as depicted at Figure 3.

4.3. Zonal Platform Systems Aspects

A reappraisal of the need for ship wide distributed systems is considered worthwhile. Conventional platform systems are commodity-providing systems with a single or dual prime generating capability and a fluid or power supply network located throughout the submarine (i.e. electrical power, cooling water, hydraulic power etc). Most submarines use distributed systems because it is considered simpler, cheaper, and better to produce a commodity centrally and then distribute it rather than to producing it locally.

However, a number of authors have commented on this topic stating that in the future, distributed systems are likely to reduce in number in favour of zonal systems to satisfy survivability, performance and quality of service requirements (Reference 8). An additional advantage is that zonal systems are likely to be more receptive to TI (i.e. adapting to meet future combat system needs and the ease of their own update as a result of increased COTS refresh rates)

One development in this topic area is the increased adoption of Zonal Power Supply Units (ZPSUs). An electrical ZPSU broadly comprises some form of bulk energy storage (e.g. Li-ion or ZEBRA secondary batteries) combined with a method of dealing with pulse energy demands
BMT Defence Services Ltd

(e.g. flywheel or super/ultracapacitor technology). Zonal systems can offer the following benefits:
- Tailoring of platform system capability to zone;
- Simpler system so easier for the operator to understand and reconfigure if required;
- Easier to isolate and reconfigure with minimal impact on the whole submarine when required;
- Easier acceptance and setting to work;
- Gains at the submarine build stage. For example: productivity, setting to work, interfaces and outfitting;
- Reduced numbers of bulkhead penetrations and cabling;
- More receptive to future TI and growth than ship wide systems.

Another benefit with respect to TI is that as the demands on the commodity provision increase, additional zonal platform systems can be inserted into the submarine to meet the increased need. It is accepted that space within the submarine would have to be allocated and reserved at the build stage for future zonal systems but the benefits of such systems are considered substantial to assist future TI. An indicative arrangement for a ZPSU is depicted at Figure 5.

Figure 5 - ZPSU Indicative Arrangement

4.4. Sizing and Margins

A key aspect of all platform systems design is sizing, for which accurate prediction of platform system requirements are essential, especially with respect to electrical and cooling demands. Undersized or even oversized systems result in a mismatch between demand and capability and they are likely to result in poorly optimised systems. Margins have always been provided for platform systems. Initially design and build margins are defined which allow for uncertainty as the design is developed from the concept stage through to construction, outfitting and entry into service. Growth margins are defined at build with consideration of a vessel's planned life to provide for unplanned growth in a vessel's weight and space. Currently, growth margins only allow for minor incremental growth. They do not tend to allow for significant changes in platform system demand following TI. Consequently, greater emphasis must be placed on estimating future TI needs in terms of growth margins and system sizing.

4.5. Adoption of Open System Architectures

The adoption of a common architecture for the electronic systems onboard future submarines will simplify the integration of components at build and through life during technology refresh evolutions. This technology should reduce the amount of cabling to be run during the installation of networked signals within the Platform Management System.

4.6. Adoption of Supporting Technologies

A number of technologies have the potential to assist TI in marine engineering systems.

Freeze techniques for isolation and repair of fluid systems have been used for a considerable time in the support of nuclear submarines. The technique normally involves clamping an insulated jacket around pipework at the point to be isolated, providing an annular space between the pipe wall and the inner skin of the jacket. A cryogenic refrigerant (i.e. liquid nitrogen) is then introduced into the annular space, creating a bath around the pipe at cryogenic temperatures. An increased adoption of this method with respect to TI and maintenance of platform fluid systems is likely to be advantageous. During maintenance periods they offer the following advantages:
- Can provide quicker and less expensive method to gain access to certain fluid systems;
- Reduce the need for costly and sometimes hazardous liquid transfer and storage;
- Potential to enable associated plant sharing allowing the same system to continue operating;
- Potential to promote system simplification and commensurate cost reduction by reducing component numbers (e.g. isolation valves etc).

(Source - www.midlandcryogenics.com)

Figure 6 - Pipe Freeze Arrangement

Reusable lagging systems which incorporate simple mechanisms for ease of removal and replacement speed up various aspects associated with the removal and installation of equipment and pipework. MODLAG®, as shown at Figure 7, is a removable and re-usable calcium silicate thermal insulation system. Each piece is molded and machined to provide an interlocking tailor-made modular package for vessels, pipework, fittings and equipment. The MODLAG® system is ideal for use in areas of limited access or on complex shapes and installations where regular
maintenance and inspection requires easily removable and replaceable insulation. (Reference 9).

Figure 7 - MODLAG® Covered Valve

Corrosion continues to be a problem onboard submarines both in pipework and castings. The needs discussed earlier in this paper with respect to increased platform life put more emphasis on the selection of appropriate materials. Otherwise re-preservation and replacement costs will increase as the life of the platform is extended. Consideration should be given to replacing all sea water systems and piping in areas of the internal pressure hull where sea water is likely to come into contact with more tolerant materials (e.g. 70/30 copper-nickel and titanium alloys) where maximum strength and corrosion resistance is required).

Figure 8 - Submarine Corrosion Issues

BMT Defence Services is exploring the possibility of “tank in tank” cooling. This means utilizing existing ballast tanks or void spaces underneath the casing but external to the pressure hull to provide fresh water cooling provision. This type of solution is more likely to lend itself to a zonal approach and should simplify and reduce the quantity of pipework fitted within the submarine.

Finally, the adoption of wireless networks should aid simplification of certain platform system control & indication functions.

4.7. All Electric Ship/Submarine

The concept of the All Electric Ship has the potential to ease the burden of TI on future submarines. The AES concept is gaining momentum in the UK and a number of overseas navies and a large selection of papers have been and continue to be published on the subject (References 10, 11, 12, 13, 14, and 15). In brief, the concept argues the use of electrical power, supplied by a set of prime movers, for all ships system needs in preference to other methods such as mechanical, pneumatic, and hydraulic. The AES concept provides an opportunity to standardise components and systems, reduce signatures and better integrate the power & propulsion system. In terms of TI it will provide an opportunity to simplify a number of platform systems reducing the complexity of integrating independent ship modifications.

Various technologies also lend themselves to AES which also have the ability to further simplify platform systems, improve overall system efficiency and assist TI. For example, substitution of hydraulic actuation where appropriate with electric actuators (i.e. either partial such as control surface control or total such as fluid system valve control and operation) will assist in simplification of boat wide platform systems in the future.

5. Proving

5.1. Overview

With an increased incidence of TI likely in the future there is a need for investment in both small and large scale land and sea based testing and trials.

5.2. Models and Simulation

Modelling and simulation are routinely used in systems design and integration and this will prove even more valuable when used for TI when virtual reality modelling and integrated CAD techniques will become ever more useful. One interesting development is the Virtual Test Bed (VTB) programme being developed at the University of South Carolina under USA DoD Office of Naval Research Funding (Reference 16). Two important aspects of the VTB make it of interest to TI. The VTB aims to be able to routinely incorporate real, full scale hardware within its simulation environment and the overall system simulation can be physically separated with the model running across a network of which the Internet itself is an obvious example. Both these characteristics would be of significant value in implementing TI.

5.3. Physical Test Bed

A good example of land and sea based trials is demonstrated by the work undertaken by Nordseewerke focused on Closed Cycle Diesel AIP systems as illustrated at Figure 9. Starting with land based trials and then moving on to more representative sea based trials they successfully tested a 250kW Closed Cycle Diesel System by utilising a decommissioned German 205 Class submarine, “Ex U1”. The programme enabled further optimisation of system arrangements, and
testing of new components including a fluid borne noise silencer (Reference 17).

Figure 9 - Nordseewerke GmbH CCD Replacement Plug

In the UK a number of TI related trials and installations have been undertaken including solid waste management treatment systems onboard CVS (Reference 18).

With respect to submarine TI, BMT Defence Services has been involved with a number of initiatives focused on the installation of replacement bilge water separation equipment (i.e. shore trial and feasibility study) and garbage processing equipment (i.e. feasibility study, shore trial and sea trials) sponsored by the UK MoD. These initiatives have offered an opportunity to de-risk TI activities, providing valuable information with respect to interfaces, installation issues and overall feasibility of the suggested TI activity.

6. Infrastructure, Management and Support System TI Enablers

6.1. TI Management and Tools

If there is to be a planned and coordinated approach to the insertion of technologies there is a need for a technology management strategy supported by a set of procedures and tools. Technology management is key to informing programme decision making processes and effectively managing technology risks. From a project perspective, technology management is a cyclic process that embraces four principal functions:
- Technology assessment;
- Risk management;
- Acquisition management;
- Planning and reporting.

Managing technology through the cycle should be an ongoing project activity that underpins the technology assurance activity and which supports project control. To assist with this process, BMT Defence Services has developed a technology management tool named Technology Management and Acquisition Planning (TMAP).

TMAP comprises a suite of integrated assessment, planning and management tools that support the selection, application and management of technology across the entire CADMID cycle. TMAP enables the technology solution space for individual programmes to be efficiently collapsed through user definable multi-selection criteria. Those technologies that satisfy the criteria may then be analysed in detail and alternative technology application pathways defined.

The objective of defining technology pathways is to seek to assure the timely availability of technology to meet the programme goals. TMAP enables the technology pathways to be prioritised, technology gaps identified and Technology Development Programmes (TDPs) to be defined.

TDPs seeks to raise the Technology Readiness Level (TRL) of a technology so that it can be developed and exploited for naval use as well as for commercial applications. The TDP seeks to de-risk those technical aspects which industry might consider to have no commercial benefit. A TDP is also used to accelerate a development process which may be too long to serve a submarine build programme if it was left to commercial development alone.

Figure 11 - TRL Plot of Potential Submarine Secondary Battery Technologies

6.2. Integration with Contractor Logistic Support Strategies

With respect to future commercial arrangements such as Contractor Logistic Support (CLS) strategies emphasis should be given to the importance of TI strategies at build.
West and Shirley (Reference 19) report in their paper that explores Future Network Enabled Capability that the Managing Director of BAE (Naval Shipbuilding) in the UK has stated that current UK government funding was insufficient to build the sort of specialised ships that the Royal Navy require. Furthermore, he hinted that, as the cost of the hull of the average warship was about one eighth of the total, the rest was for the purchase and insertion of systems. The additional task of making these network ready went well beyond any costing thus far considered.

6.3. Configuration Management Strategies and Systems

Interface definition and recording is as important for platform systems as for combat systems. It is likely that the key opportunities for technology insertion in platform systems are likely to come at the partial system and equipment level. However, these can only be investigated if the systems engineering knowledge of the overall system architecture is maintained. Effective use and increased adoption of processes and tools to support this are deemed essential to support efficient, effective and successful TI.

7. Barriers

Recent work undertaken in the UK (Reference 20) has identified the following barriers to TI which are also considered appropriate to platform system TI:
- An inability to determine the impact and cost of technology insertion downstream has resulted in an unwillingness to spend;
- The current in-service support policy doesn't motivate business to do better;
- There is a lack of demonstrators to mature technologies to appropriate levels.

These aspects amongst others must be overcome in order to facilitate smooth TI in the future.

For long-term projects affordability, timescale, priorities and technology insertion plans need to be shared between the MoD and industry wherever possible. This will allow suppliers to make informed and focused investment decisions and assess opportunities prior to commitment. In addition, it will allow early notification and will also enable suppliers to participate in the process of identifying trade-offs between performance, time and through life cost.

It is likely that the refresh of ageing and obsolete technology will enhance the relationship with suppliers who also favour the turnover of new equipment rather than the support of old items. Suppliers do not favour the large overheads of dealing with the MoD to support a handful of obsolete items: they would rather sell their current best products and use the MoD application to enhance their status as a leading current-day supplier.

8. Conclusions

The need for TI in platform systems has been explored in this paper. A number of TI enablers in areas such as technology, infrastructure, management and support system have been discussed and a number of examples described.

Future submarine designs must aim to be sustainable, adaptable and above all affordable. A co-ordinated and well conceived TI strategy will assist in meeting this aim.

TI will not offer its full range of potential benefits without fully including it in the earliest concept stages of a design. Planning and designing for TI is deemed essential for both combat and platform systems.

Design for a class of vessels as a contiguous whole can no longer be afforded. It is inconceivable that modern navies can continue with the traditional development and support regimes focussed around classes of warships and submarines.

It is considered unlikely that designing for TI will not come without a Unit Procurement Cost (UPC) increase. Consequently, clear savings in through life costs must be demonstrated. Only then will submarine designers and manufacturers have an opportunity to truly maximise the opportunities for TI in future submarine designs.

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10. References


