MANAGING THE UK ELECTRIC SHIP PROGRAMME

A REVIEW AND LOOK TO THE FUTURE OF DECIDING WHERE TO INVEST

BY

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ABSTRACT

The current strategy for the development of marine systems for the Royal Navy is defined by the Marine Engineering Development Strategy (MEDS) paper, which was endorsed by the Navy Board in 1996. MEDS has withstood the test of time well, however, it was written prior to the Strategic Defence Review and the introduction of SMART Acquisition, available technology has moved forward and further environmental constraints have materialized. In addition MEDS is not placed within the context of current wider Defence programmes and strategies. The focus and direction provided by the MEDS has guided investment decisions for the last 6 years resulting in successful and coherent programme. With the earlier than expected adoption of Integrated Electric Propulsion for the Type 45 Destroyer, and faster than expected advances in relevant technologies, it is timely to review the strategy to ensure the required focus and direction is maintained. The principles that underpin the MEDS remain valid, it is the application of these principles that is in need of review. This article will address these issues, cover the changes in the environment since the original MEDS, present a method for managing MoD investment in Marine Engineering development that makes use of Technology Readiness Levels, and give headlines where future investment may take place in 2003 and beyond.

Introduction

Marine engineering in the Royal Navy has undergone between 2 and 4 major evolutions since the end of the 19th Century, the number depending on the age, speciality and bias of the article's author(s). The move from sail to steam is well recognized and documented. The move to industrial derived gas turbines in the late 1960's was achieved in the Royal Navy by the introduction of the G6 Gas Turbine engine on the County Class Destroyers and the singleton Type 82 Destroyer, HMS *Bristol*. This was taken further with the introduction in the 1970s of aero-derived gas turbines as the sole means of propulsion (the G6 GT being used in conjunction with a steam plant on the county and T82 destroyers) for the Types 21, 22, 42 and Aircraft carriers. This totalled 35 ships with 4 propulsion gas turbines in either Combined Gas & Gas or Combined Gas or Gas configuration. The transition to this form of propulsion was completed in the early 1990s with the decommissioning of the last LEANDER frigate with steam propulsion. Only the 2 LPDs and the Royal Yacht remained with steam propulsion. The final historical revolution for the Royal Navy occurred when HMS *Norfolk*, a Type 23 frigate, entered service in 1990 with a Combined Diesel Electric And Gas Turbine (CODLAG) propulsion plant. This introduced, for the first time in the world, an integrated propulsion and ship service load generating plant concept for part of the ships operating profile. Four equally sized diesel generators providing both propulsive power and ship service load up to a ships speed of around 16 knots, before a gas turbine is directly clutched in to take to ship to in excess of 29kts. Whilst this arrangement was created primarily to meet signature requirements of anti-submarine warfare, it has given many other benefits.

By the mid-1990s eight T23s were in service and significant capability enhancements and economy was being demonstrated, especially when on electric drive. Aligned to this was a shift in the commercial marine market in its approach to propulsion and power generation. At this time several visionaries in the MoD Procurement Executive saw the opportunity for a further revolution in the Royal Navy's approach to marine engineering. A small team worked on generating a strategy, concept and development programme. This resulted in the Marine Engineering Development Strategy, which set out the goals, opportunities, hurdles and stimuli for advancing marine engineering, and thus improving operational capability and economy. The Marine Engineering Development Strategy (MEDS) set out the Royal Navy's vision of the Electric Ship Concept and the All Electric Ship (AES). Of more significance is the endorsement that was gained for the MEDS. The full Navy Board endorsed the paper in 1996, and Government Ministers noted it in the same year. It was this act that effectively stated that the naval vessels of the future would be Electric, the first navy in the world to do so, and consequently secure the funding to start the Electric Ship Programme Office (ESPO) and Marine Engineering Development Programme (MEDP). It was at this point in 1996 that the question of how to build a programme of technology developments and demonstrations was first encountered. This had to be done within a limited budget, meeting tight timescales and giving the best return on investment.

Building a programme in 1996

The conceptual Electric Ship architecture was set out in the MEDS, along with the headline goals of an all gas turbine ship, power dense electric motors and generators, adoption of advanced power electronics and the widespread electrification of ships auxiliaries. The final tenet of the strategy was the need to comply with emerging environmental legislation. Target platforms were identified from the future naval plans. These were the future submarine, future carrier and future surface combatant (frigate). All the platforms were in the pre-concept or concept phases of development with key decisions points on the power and propulsion systems due in the 2003-2010 time frame. The ships and submarines would be entering service from 2013 onwards. This set the scene for building a programme.

The programme was generated using mainly bottom fed, technology biased, proposals from the technical specialist sections within the then Director of Marine Engineering's organization. This was mainly due to the future platforms being early in their development cycles and being unable to provide much of a focus for development. Systems development and larger cross platform aspects were added to the candidate list of projects by the Electric Ship Programme Office (ESPO), now containing several industry secondees. All candidate projects were considered against a set of weighted requirements and criteria. This produced a balanced programme of 60 separate work items over a 5-6 year time frame. This programme of work was co-ordinated by the ESPO and made up the Marine Engineering Development Programme (MEDP). The work items included:

- Small conceptual and feasibility studies (generating the requirements for later Technical Demonstrator Programmes (TDPs)) – 20%.

- Fuel and system models for assessing technologies and configurations – 5%.
- Small equipment and sub-system Technology Demonstrator Programmes – 30%.
- Large equipment and system TDPs – 45%.

The percentages quoted at the end of each task line represent the rough split in funding for each task. This split ensured sufficient work was generated from the first two tasks to sustain a programme, and sufficient funds were available to carry out meaningful development and demonstration of technologies. It was recognized from the beginning that demonstration of the candidate technologies for an AES would be necessary before they could be adopted in a future platform. This need has only increased following the introduction of SMART Acquisition and Prime Contractorship.

Reviewing the programme in 2002

Since the endorsement of the MEDS in 1996 and the beginning of 2002 the following events, external to the ESPO, occurred:

- The Strategic Defence Review changed the UK's defence goals and missions to a more expeditionary force structure.
- The SMART Procurement Initiative was introduced, followed by its evolution to SMART Acquisition.
- The Procurement Executive was formed into the Defence Procurement Agency (DPA) to manage the adoption of SMART Acquisition.
- The Defence Logistics Organization was created to manage the logistics and in service support for all three armed services.
- The US Integrated Power System (IPS) Full Scale Advanced Development programme demonstrated the feasibility of large electric drive components for warships.
- The US Navy and 3 other European Navies declare their intent to go to an All Electric Navy.
- The UK's Auxiliary Oiler and Landing Platform Dock (LPD) projects select commercial Integrated Electric Propulsion (IEP) systems for their propulsion and power distribution systems.
- The UK's T45 DARING Class Destroyer Project selected an IEP solution for the first 6 ships of the class – a World First for a front line warship.

The factors listed above are all significant events in the evolution of the Electric Ship Concept and the standing and position of the ESPO. The two events that caused the most impact on the business process of the ESPO was SMART Acquisition and the selection, late in the decision process, for the T45 to have an IEP system. SMART Acquisition removed the opportunity to mandate equipment and system choices on the shipbuilder, greatly reduced the influence of the centre of excellence in engineering built up over many decades in the MoD and attempted the wholesale transfer of the risk of ship design and build to the Prime Contractor. The adoption and implementation of the SMART Acquisition principles are still the main drive of the DPA, but considerable lessons have been learnt with the current in build or design warship and auxiliary ship projects.

In addition to the external factors listed above a number of internal changes occurred that lead to the review of the programme and its business process at the start of 2002. These are listed below:

- The initial phase of the work was coming to a conclusion – the step change in technology to IEPs had been achieved and a period of consolidation and evolution was being started.
- Funding and long term programme reviews saw the closing down of the Future Attack Submarine (FASM) Project. This removed one of the 3 prime target platforms for the Marine Engineering Development Programme (MEDP), which included the Electric Ship Concept.
- Funding and medium term programme reviews saw the Future Surface Combatant (FSC) Project reduced in size and put back into the concept phase of development. This effectively moved the in service date for this vessel to beyond 2015. This virtually removed the second of the 3 prime target platforms for the MEDP.
- The ESPO changed its management chain due to the demise of FSC as a fully fledged Integrated Project Team (IPT). The ESPO moved to become part of the Future Business Group, a support group of the DPA.
- The Head of the Electric Ship Programme Office (ESPO) changed.

The rapid internal changes in the first two months of 2002 necessitated that an urgent review be carried out to answer the following questions, being asked by several senior staff in the MoD:

- The Electric Ship Concept is being delivered in the T45, so why should the ESPO still exist?
- All the headline developments in the MEDP are either complete or close to finishing, so what now?

These questions will be explored as themes through the remainder of the article.

Characteristics of a programme

The review of the MEDP and Electric Ship programmes was carried out using internal resources, but involved wide consultation with all stakeholders, both contributors and customers. It was decided early to apply commercial business processes and methods to the programme. This highlighted that the ESPO was very similar to a venture capital business in the commercial world. It had to:

- Justify its funding.
- Manage risk and work effectively.
- Manage staff.
- Manage assets.
- Adapt to external changes and influences.
- Finally 'sell' its product.

The beginnings of a process map began to emerge. The first attempt at this from March 2002 is shown in (FIG.1).

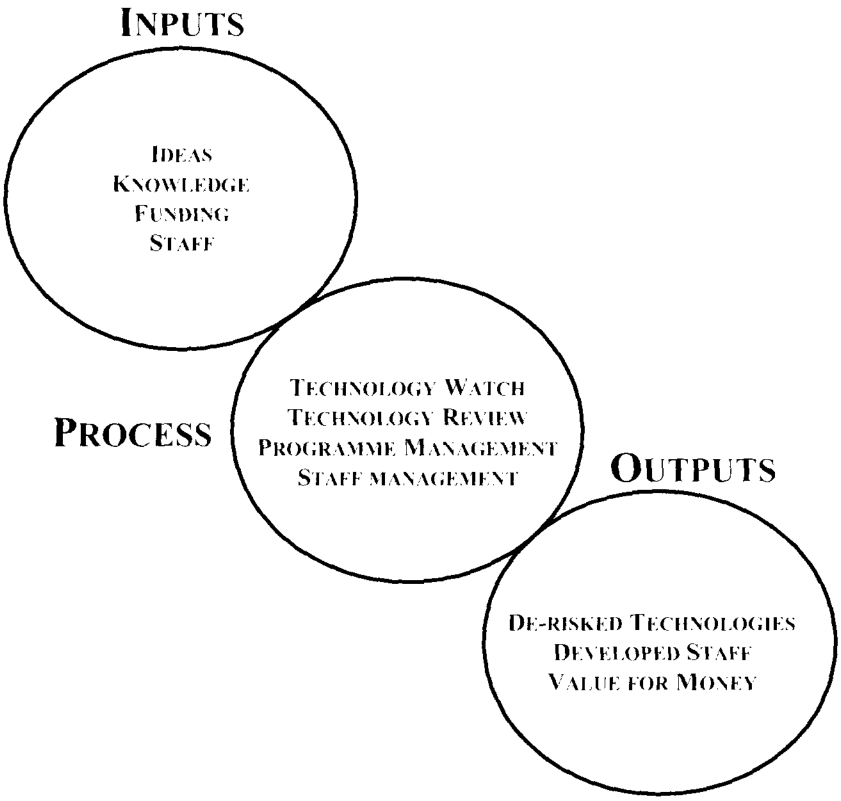

FIG.1 INITIAL OUTPUT OF BUSINESS PROCESS REVIEW

The work put into producing FIG.1 showed that the ESPO was the most basic of businesses: it had inputs, carried out a process, and had outputs. As with all businesses there were successes and failures, external bodies who had an influence, and customers to keep happy. There was work for the here and now, exploratory work for the future, and marketing. Business was on an international scale; alliances, partnerships and co-operative working practices were all present and being actively pursued. Extramural activities were encouraged, staff training was happening, staff changed and reputations were built. All this showed that the decision to view the ESPO as a business was the right one.

Further analysis and consultation found that the ESPO had been doing well as a business since its inception in 1996. It was a world recognized Centre of Excellence for Electric Warships and was running a multi-million pound development programme where over 80% of it's developed technology had been pulled through on to warship or auxiliary platforms due to enter service from 2002 onwards. In addition the ESPO was acting as a technology consultancy service to all future naval platforms in the DPA and played a valuable role as part of the core staff of the Warship's Support Agency (WSA) Director of Operations Equipment's (DOPSE) Centre of Excellence for Marine Engineering. All this was being achieved with a staff of six for the majority of 2002. All this review work was valuable, but still didn't answer the questions at the end of the previous section. Where was the ESPO business to go in the future? Should it still exist after its current workload and projects complete in 2004? To answer these questions a clean sheet approach to the ESPO's Business Process was taken.

New ESPO Business Process in a Changing Acquisition Environment

Alongside the internal ESPO review several other documents were published that would have to be factored into the new business process. The latest Major Projects Review[1] by the National Audit Office, the DPA's Technology Strategy[2], the MoD's Technology Strategy Issue 3[3], and the MCKINSEY Report on DPA performance[4] all had a common theme – Technology Management was a weak point of the Acquisition Process. The lack of clear technology management has been the most significant contributory factor in 66% of in year slippage and 75% of performance shortfalls. Initiatives and plans were put in place to overcome this issue for the DPA and MoD as a whole and it was recognized that anything the ESPO did in the future would have to fit in with the wider technology management review. One of the key themes of the technology strategies being developed in the MoD were Technology Readiness Levels (TRLs) and Technology Roadmapping. It was decided to use these methodologies as the baseline for the new ESPO business process.

TRLs[5]

TRLs were initially proposed by NASA in 1995, and following sporadic use within the US Science and Technology Community, were adopted by the US DoD in June 2001 where they are now mandated for all major Acquisition programmes. Within the UK MoD TRLs were initially used by the Future Offensive Air System IPT, following which they were proposed as a generic tool for managing technology risk. Draft guidance on TRLs was first published in July 2001 and since then a number of IPTs within the DPA have begun using or assessing TRLs for applicability to their projects. In an attempt to improve technology management and reduce programme delay, the wider use of TRLs within acquisition was recommended by MCKINSEY and has now been mandated on DPA projects by the Chief of Defence Procurement and by the Chief Scientific Advisor on the research community.

TRLs provide a structured means of measuring, and communicating, the maturity of technologies within MoD acquisition programmes. The technique complements other means of programme risk assessment. Also, by assessing the risk of achieving each technology readiness level it is possible to determine, and hence manage, the risk within individual technology programmes. (FIG.2) shows the 9 levels of TRL and their simple definitions.

LOW	1.	BASIC PRINCIPLES OF TECHNOLGY OBSERVED AND REPORTED
	2.	TECHNOLOGY CONCEPT AND/OR APPLICATION FORMULATED
	3.	ANALYTICAL AND LABORATORY STUDIES TO VALIDATE ANALYTICAL PREDICTIONS
MEDIUM	4.	COMPONENT AND/OR SUB-SYSTEM TECHNOLOGY VALID IN LAB-ENVIRONMENT
	5.	COMPONENT AND/OR SUB-SYSTEM TECHNOLOGY VALID IN RELEVANT ENVIRONMENT
	6.	SYSTEM/SUB-SYSTEM TECHNOLOGY MODEL OR PROTOTYPE DEMO IN RELEVANT ENVIRONMENT
HIGH	7.	SYSTEM TECHNOLOGY PROTOTYPE DEMO IN AN OPERATIONAL ENVIRONMENT
	8.	SYSTEM TECHNOLOGY QUALIFIED THROUGH TEST AND DEMONSTRATION
	9.	SYSTEM TECHNOLOGY QUALIFIED THROUGH SUCCESSFUL MISSION OPERATIONS

INCREASING MATURITY

FIG.2 THE TECHNOLOGY READINESS LEVEL FRAMEWORK

Crudely; levels 1 to 3 relate to technology development, and levels above this to the maturation of design application. In the case of technology development, level 1 represents basic science research and level 3 is the point where the performance attributes critical to use in a practical application are demonstrated. By definition, application concepts have not been explored in any detail at this stage. Differentiation between levels 4 and 5 represents the transition from laboratory to 'real world" demonstration. In the case of a control system component, level 4 demonstration might be exemplified by artificial stimulation of response from the component (i.e. the representation of the system of which the component is part remains virtual). This can be compared with level 5 where the test component is demonstrated to work within a physical realization of the overall system (i.e. any stimulation is to the external system). The test component at level 5 might be representative of the technology or design proposed for the intended system application, however the overall demonstration system would not be representative (i.e. other physical elements within the demonstration would not replicate the fit or form of the intended application). Above level 5, demonstration is of system prototypes or models (representative of form and function) with increasing similarity to the production system (level 8), culminating in completion of bug fixing on the final article at level 9, which will typically be cleared for operational use.

When considering technology maturity, it is important to understand how a project's dependency on technology evolves through its life. During concept, a wide range of technologies should be considered, and as the project progresses the range of options (and hence the range of technology upon which the project depends) will reduce. An illustrative example of this 'technology funnel' based on propulsion options for a future frigate sized ship, which does not quantify the maturity expected at each stage, is given in (FIG.3).

PROPULSION OPTIONS

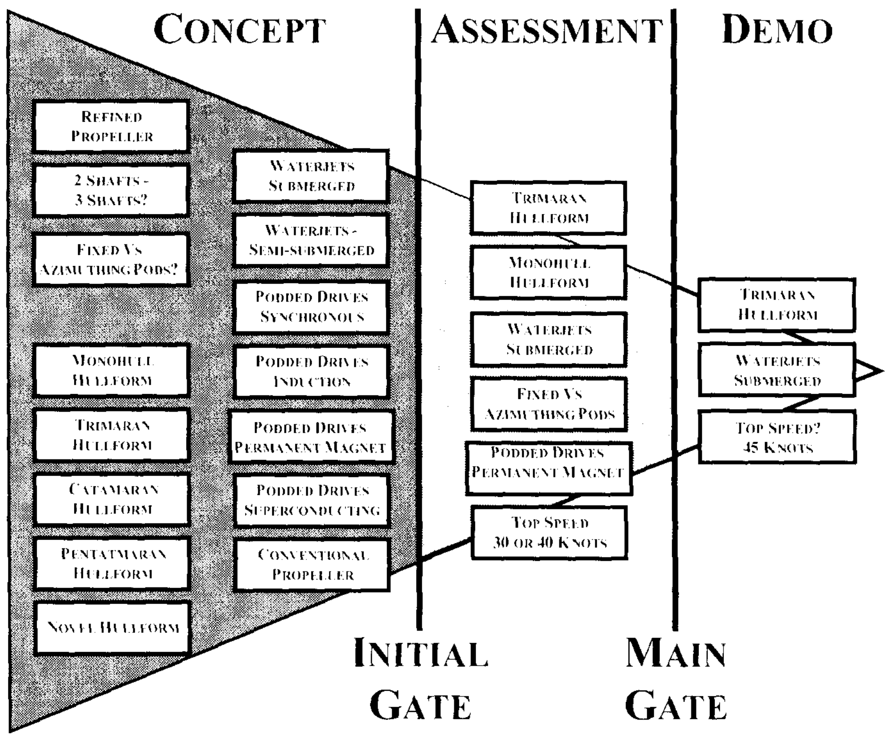

FIG.3 EVOLUTION OF PROJECT TECHNOLOGIES

Whilst it must not be forgotten that different technologies evolve at different rates, evidence suggests that there is a strong correlation between the level of technology maturity at Main Gate and the subsequent delay experienced by the programme[4]. (FIG.4) illustrates the different levels of technology maturity typically associated within acquisition and research activities. It should be noted that the diagram illustrates the latest opportunity for technology insertion rather than idealised programme.

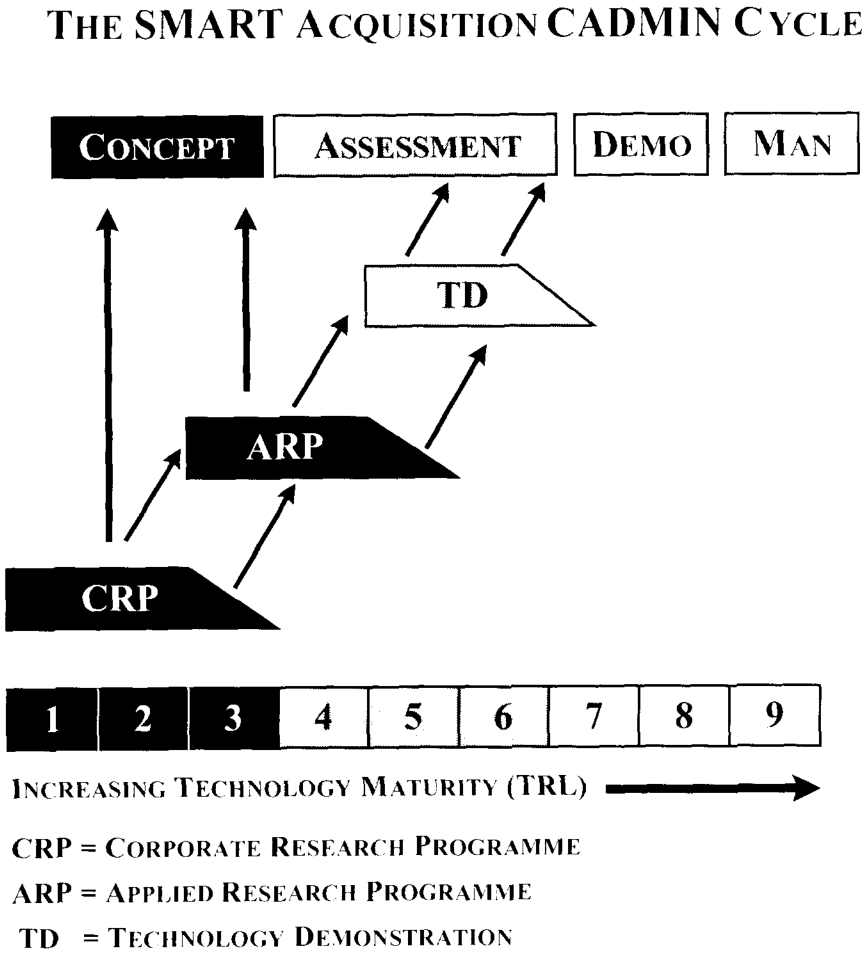

FIG.4 TECHNOLOGY MATURITY WITHIN CADMID

Technology Roadmapping

Technology Roadmapping takes the base information (TRL assessment and predictions) on individual technologies or systems and applies the project's performance, timescale, cost and risk constraints to form a plan for technology exploitation and development. From this process a TD Programme is produced for all the technologies that have an application in that project. It is this process that has been missing in the past, and it is this process that the new ESPO business process will concentrate on.

The new TRL Databank and ESPO Business Process

The basic business process model, FIG.1, for the ESPO was used to generate a new business process map that used TRL assessments on marine system technologies, incorporated the latest target platform timescales and constraints and then generated an investment plan for marine systems development for future naval platforms. The new business process map is shown in (FIG.5).

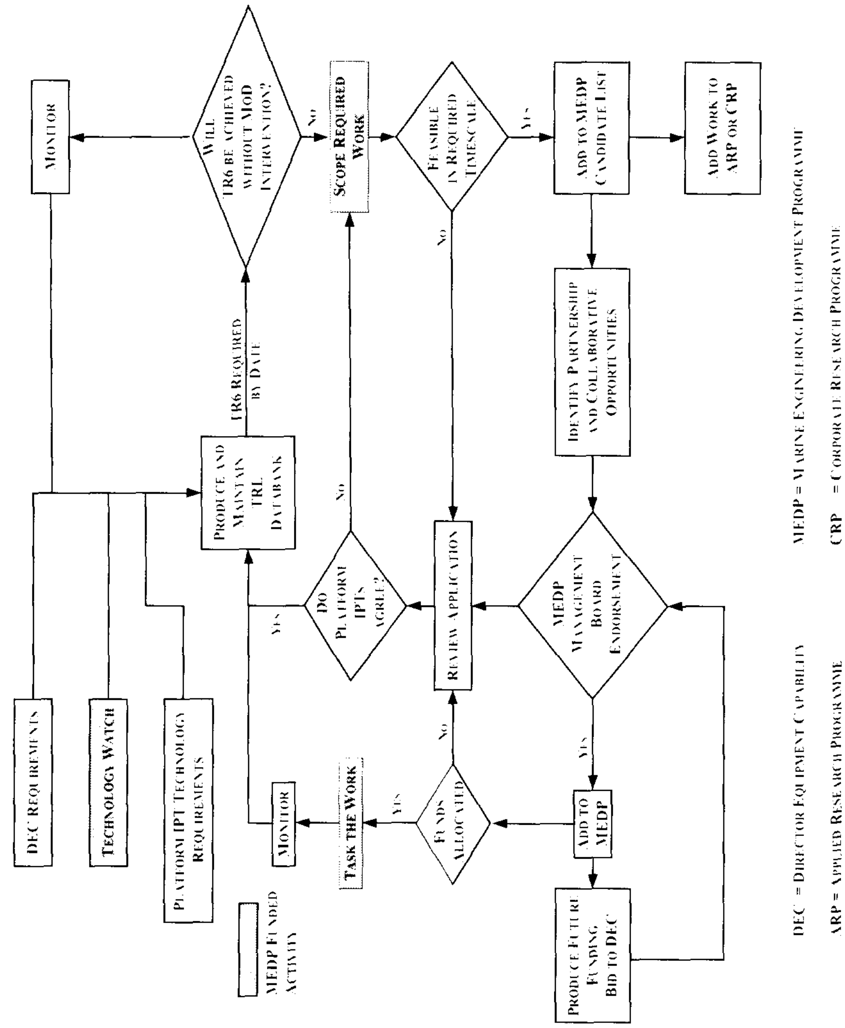

FIG.5 NEW ESPO BUSINESS PROCESS

It can be seen that the TRL Databank is the centrepiece of this process, and acts as the knowledge store and part of the ideas generator for the building of the new Marine Systems Development Programme. The business process will be described following a brief outline of the TRL databank.

Work to build the TRL Databank started in the summer of 2002 and should complete in Jan 2003. Structuring the databank took several attempts, and care was taken to bound the range of technologies to be included in issue 1 of the databank, to ensure completion in a reasonable timescale. Surface ship marine systems were the boundary, submarine technologies would follow in 2003. By December 2002 over 1,500 lines of technology had been identified, assessed and recorded. The databank had two levels of technology breakdown and focused on technologies and not products. The technology lines were then assessed for their TRL for 2002, and then, more importantly, the prediction of the TRL for that line was made out to 2014. This prediction was made on the assumption that no MOD funding would be used beyond current contracted work, and that the TRL assessment was for using the technology in a Royal Navy/Royal Fleet Auxiliary vessel. This meant meeting current UK MoD standards for military use. Other guidelines and instructions developed as the databank was populated. Commercial Off The Shelf (COTS) technologies became an issue, with the decision that COTS equipment and systems could only reach TRL 6 as they would not have been demonstrated in a 'representative environment' (naval) as required by the TRL 7 and above definitions (FIG.2). Technologies in foreign military use, but not UK military use were also considered. Each was considered separately against the criteria and standards in the country of origin for the technology and those in the UK. A TRL no higher than 7 for technologies is use by dissimilar navies to the UK, and TRL 8 for similar navies could be recorded.

Each entry in the TRL databank had to be supported by references, to show where the technology came from, or how the TRL assessment and prediction was generated. All the references quoted would have to be open source information, no MoD restricted reports would be listed. Each technology line would have an identified MoD sponsor and owner. It would be their responsibility to generate the technology lines for their areas of responsibility, make the initial TRL assessment and prediction and then keep their lines up to date. The ESPO would act as the overseer and co-ordinator of the databank, owning less than 10% of the technology lines. The remaining 90% of the lines in Issue 1 will be owned by desk officers in the technical IPTs of the WSA, the Marine Engineering Centre of Excellence.

The aim from the beginning was to publish the databank as an open, unclassified, MoD viewpoint on the range of marine systems technologies listed in the spreadsheet. The aim of publishing the databank as widely as possible was to aid the role of technology watch that all engineers in the acquisition community have, to increase the flow of information between industry, academia, the research community and the MoD/DPA and finally to assist in tackling the wider technology management issues highlighted in the MPR[1] and MCKINSEY Reports[4]. There are many secondary aims of the databank, ranging from improving international exchange and co-operation, identifying training gaps, forecasting obsolescence issues, improving internal communication and co-ordination, removal of duplication of effort and identification of clear technology leaders. It is planned to publish Issue 1 of the databank in spreadsheet format in early 2003. The mid term aim is to convert the databank to a format for publication on the Internet. A partner will be sought to run the website, and manage the dataflow between the external (industry, academia, research community) and internal (DPA, WSA, DSTL etc) stakeholders.

FIG.5 shows the complete new business process. The ideas generation part of the process, top left, includes:

- The tri-service requirements organization (Director Equipment Capability (DEC)) in MoD Centre.
- The WSA technical desk officers carrying out their Technology Watch role.
- The DPA future platform IPTs.

All these people, including hopefully industry, academia and the research community after Issue 1 of the databank, generate the ideas for technology inclusion in future platforms. This information is captured in the TRL databank. The candidate platforms for the technology or system are then considered and an assessment made as to whether the technology will mature, without MoD funding in time for the platform's initial gate and main gate submission. This is important as it has now been mandated that DPA IPTs show the technologies that they wish to include are at TRL 3 and above at initial gate and those chosen for inclusion at main gate are at TRL 6 (see technology funnel in FIG.3). The second of these is the critical issue as MEDP aims at developing and demonstrating technologies in the TRL range 3-7.

If the technology or system is assessed as being mature enough already, or will mature without MoD funding in time for the projects main gate submission, the monitor/technology watch role is maintained. If, however, the TRL prediction has the technology falling below TRL 6 by the time it's needed for a certain project, scoping is carried out to establish the work required to accelerate the maturity of that technology in time for the project. The feasibility of that acceleration is then assessed. If this results in a negative assessment, this is reviewed with the candidate platform, discussed with other possible candidate platforms and the DEC and a reassessment or removal of the technology from the platform 'wish list' will occur. This information will be fed back into the TRL databank.

Once a technology development (TRL acceleration) has passed the scoping and feasibility stages it will be added to the MEDP candidate list. As with all programmes using Government money any work has to be justified, scrutinized and approved. In addition to this there is always more work to do than there is money to do it. The remainder of the business process explores the justification, value for money and approvals routes for any MEDP work item. A key feature of the new business process is the much earlier consideration of industrial and international partnerships and collaborations. New contracting opportunities and methods allow the MoD to play a more proactive roll in contracting and product development.

The Future Marine Engineering Development Programme

During the development of the new ESPO business process and TRL Databank the 2002/2003 MEDP has been underway with 41 running work streams covering such subjects as:

- Integrated waste management.
- Variable speed drives.
- Advanced cycle low power "diesel beating" gas turbine.
- The construction and commissioning of the Electric Ship Technology Demonstrator.

Throughout the year the plans for the MEDP in 2003 and beyond have been considered and developed. Revised funding routes and requirements have been established, a new Approvals Procedure has been developed and introduced and the programme management software tool used has been updated and released to all users. In addition to this the new business process has been reviewed by all parties involved in the ESPO and MEDP business and has received full endorsement. As the TRL databank work nears completion and the detailed planning of next years programme begins it is possible to outline some of the headlines and up and coming technology priority areas in this article.

Technology Headlines from the Equipment Customer

As the Equipment Capability Customer (ECC – DECs) organization beds in since its formation from the Director of Requirements (DOR) organization of the late 1990s it has been possible to articulate a set of high level requirements/objectives for marine engineering systems of future naval platforms. These have been distilled down to the following:

- Cost of Ownership.

- Maintaining affordable Capability in legacy Platforms.
- Performance (Capability).
- Environment.
- Signatures.
- Vulnerability.
- Recoverability.
- Platform Integration.
- Marine System Enablers.

Technology Thrust Areas for Future MEDP

From the headline requirements above, and using the knowledge in the ME Centre of Excellence and ESPO a programme for 2003 and beyond has been generated. The list of technologies for development is extensive and would spend the current funding allocation twice over. The programme generation, at time of writing, is at the bottom left hand corner position of FIG.5. The approvals and scrutiny process will produce a balanced programme within the budget allocated, in time for the start of the next financial year.

The technology development list includes the following work:

- Fast Ship – in support of potential future decisions for FSC.
- Integration of next generation combat system Developments (Pulse Forming Networks and Linear Launchers).
- Ensuring that the operation of platforms is not constrained by environmental and Health & Safety legislation.
- Optimized Manning.
- Propulsor Solutions.
- Automation of the internal battlespace – to improve resilience and response to damage whilst minimizing the exposure of individuals.
- Longer term fuel availability.
- Heat Management.
- Platform Management Systems.

Work is due to start in 2003 in all of the above areas. Existing items like the Electric Ship Technology Demonstrator, Advanced Cycle-Low Power Gas Turbine Alternator, Platform Management Systems, integrated waste management, firefighting technologies and actuators will continue and evolve. In total it is planned to run a programme of 30-40 projects ranging from scoping and feasibility studies up to full-scale demonstrator projects.

The work currently being conducted in the MEDP, and the new items being started or investigated, all aim at being included in ship designs either from the initial design, as technology insertion candidates for later batches of new ships. Many of the work streams also consider back-fit options for the existing fleet. All items aim to reduce the cost of ownership of marine systems and equipment and to improve the operational capability of the vessel, class of ship and the fleet as a whole.

Conclusion

Several visionaries within the MoD came to a common view in the mid-1990's that the potential existed for a revolution in naval marine propulsion, power generation and distribution. The Electric Ship Concept was born, closely followed by a Strategy backed by the Navy Board that stated the UK's intention to go to All Electric Ships for the core of the future Royal Navy Fleet. This included the Future Carrier, Future Attack Submarine and Future Surface Combatant. Since the strategy was endorsed in 1996 all major vessels for the Royal Navy and Royal Fleet Auxiliary have had versions of the Electric Ship Concept. Integrated Electric Propulsion has been selected for the 2 LPDs, 2 Auxiliary Oilers, Trimaran Demonstrator, 2 Survey Vessels and the 6 Type 45 Destroyers on order.

The Electric Ship Programme Office, in existence since 1996, has been hugely successful in picking winning technologies, developing and de-risking them, and then getting them included in the designs of future warships. This is demonstrated by an 80% pull-through rate, in 2002, for the investment made by the ESPO since 1996. No other MoD funded research and development programme reaches this level of pull-through.

The review carried out in 2002 found that whilst the main aims of the original MEDS were still very relevant and valid, the operating environment and outside constraints on the programme had changed. The review found that many of the SMART Acquisition principles were already incorporated in the MEDS, and had contributed to the success stated above. The two questions that kept arising early in the review, listed below, were considered throughout the generation and discussion period for the new ESPO business process.

- The Electric Ship Concept is being delivered in the T45, so why should the ESPO still exist?
- All the headline developments in the MEDP are either complete or close to finishing, so what now?

The adoption of Technology Readiness Levels as the basis for generating and then managing the MEDP would ensure a broad range of technologies (1500+ lines of technology are present in the TRL Databank) are assessed for their potential application in naval platforms. The new business process ensures a robust sorting and approval mechanism exists to sustain the MEDP in the future. The adoption of TRLs, the new business process and the newly defined objectives and technology pointers from the Equipment Capability Customer mean that both of the above questions can now be answered. The ESPO should still exist beyond the T45 as a technology management office on behalf of the ECC and DPA and WSA IPTs, with the aim of facilitating the timely adoption of emerging technologies to ensure early realization of benefits and capabilities. The question on what comes next after the main headline goals of the original programme had been met has been address by the new objectives/requirements from the ECC. These are more capability based and provide a very sound background for targeted technology development, the very strength and core business of the ESPO and MEDP.

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