Battlespace access

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As damage to or loss of manned systems becomes increasingly politically sensitive, AUVs are becoming a more attractive and accepted resource within most nations' war-fighting portfolios.

Low	1	Basic principles of technology observed & reported
	2	Technology Concept and/or Application Formulated
	3	Analytical and Laboratory Studies to validate analytical predictions
Medium	4	Component and/or basic sub-system technology valid in lab environment
	5	Component and/or basic 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 & demonstration
	9	System technology 'qualified' through successful mission operations

Increasing Maturity

Figure 1. The Technology Readiness Level (TRL) scale.

The UK Ministry of Defence (MoD) has recognised the potential of exploiting the significant operational advantages offered by unmanned underwater vehicles, including extension of its (the MoD's) resources through the ability to operate independently for extended periods, enabling manned platforms to extend their reach and focus on more complex tasks; minimising or eliminating the risk to personnel and expensive platforms through autonomy; mission flexibility through their ability to be deployed from a variety of host platforms including submarines, ships, land and aircraft; their stealth; and environmental adaptability. Broad area denial is a real threat, given the technology trends with the use of satellites and missiles. Undersea systems may be the only early entry to battlespace to enable effective achievement of 'war' objectives providing a force multiplier.

The Battlespace Access Unmanned Underwater Vehicles (BAUUV) research programme has been defined by the MoD Directorate of Equipment Capability – UnderWater Effects, with the objective to address the critical component and sensor technology areas to minimise the risks of the development of the BAUUV and enable successful technology integration into existing and future battlespace platforms. The future has been defined in the 2011/15 timeframe and beyond. The generic component technologies that are considered to be fundamental to the operation of any BAUUV are defined as:

- communications
- onboard data handling
- navigation
- sensors and payloads
- energy storage and propulsion systems
- command, control and mission management (CCMM)

All of these key technology areas are brought together by the consideration of design and integration issues and the interfaces to a full range of potential host platforms, particularly with regards to launch and recovery systems.

As prime contractor, Systems Engineering & Assessment Ltd (SEA) has assembled a unique team of experts and subcontractors to identify, develop and demonstrate specific applicable component technologies for a new generation of BAUUV. Its major subcontractors, Southampton Oceanography Centre, UK, and Subsea 7 support SEA in addressing the objective. In addition, SEA is consulting a large team of world-class technology expert companies and university departments to understand the status of the technologies for the future BAUUV.

The approach

SEA's approach has been informed by a thorough understanding of the organisations and policies that must work together successfully to ensure that defence research expenditure is effectively managed to achieve the early delivery of effective military capability with least risk. The central objective is to deliver a progressive, balanced appreciation of the potential for a militarily effective BAUUV with choices between solutions, technologies and sources supported by rigorously assessed test data evaluated in operational models that will be readily understood by technical and operational staff.

The three-year project began in January 2003 and is split into three phases to efficiently address the objectives of the BAUUV research programme. Phase 1 established the technology benchmark and defined the detailed technology development plan relative to the mission and system needs, prioritised via a Balance of Investment (BoI) process conducted by a steering committee. An extended Phase 2 is progressing the development of the technologies to eventually fill the military gaps and demonstrate these at component or subsystem levels. As the technology definition and developments progress through Phase 2, an integrated system trial, utilising the SeeByte Rauver testbed vehicle, has been defined for Phase 3 in 2005. In Phase 3, the integrated system trial will bring together and demonstrate a number of the technologies developed under the project and provide the essential definition of a possible BAUUV to assist the customer with its procurement process. A continuous BoI process facilitates the regular readdressing of technology development priorities.

A key feature of the approach is the adoption of strict systems engineering disciplines to ensure that the programme is tautly managed and reaches its objectives. Great emphasis has been placed on the verification of Technology Readiness Levels (TRL), through the collection of a structured and auditable body of evidence encompassing analysis, simulation, bench tests and trials in a relevant environment.

Focus on capability

To enable this programme to explore the operational benefits, which could realistically be delivered by BAUUV in the 2011 timeframe and beyond, SEA has developed the range of military activities that might be required by the user. This definition of potential employment has been produced taking inputs from a wide range of key stakeholders within MoD, academia and the project team.

The Mission Capability Statement (MCS) is designed to radically enhance the operational capability of military systems and as such provides a reference for the definition of the technology gaps for the future BAUUV. Defining a large list of classified missions, some deliberately challenging in terms of the requisite technologies, the MCS forms the first step in developing BAUUV user and system requirements. While a priority list of missions has been agreed with the customer, maintaining the focus of capability, the programme will continue to de-risk technologies applicable to the full range of missions.

Technology readiness

Technology Readiness Levels provide a structured means of measuring and communicating the maturity of technologies within MoD acquisition programmes (see Figure 1). Complementing other means of assessing programme risk, the TRL assessment helps determine, and hence manage, the risk within individual technology programmes.

While the TRL scale provides a good mechanism for assessing the readiness of a component technology for employment, the equivalent System Integration Readiness Levels (SRL) provide a simple taxonomy to support project planning and to assess system maturity. Technologies and equipment readied relative to the TRL scale does not necessarily make it ready for integration into a 'system'. Thus the MoD has introduced the SRL scale to de-risk the transition of technologies into the Equipment programme (see outline in Figure 2). The BAUUV programme is assessing the readiness of technologies relative to both of these scales.

Optimisation of the component technology development programmes will be supported by operational analyses and cost effectiveness studies to assess future UUV concepts in operational scenarios.

Technology assessment

Bringing to bear the combined expertise of the project team, a full view of the key technology areas has been achieved and the data captured in the BAUUV Technology Bank. The Bank, to date, contains approximately 300 technology datasheets including TRL and SRL assessments against each technology. The data is captured in a database format and the first drafts have been utilised by the MoD for early exploitation opportunities.

An environmental impact and a Through Life Cost (TLC) assessment are underway for each technology area. A bottom up approach to TLC will support the MoD in developing its procurement business case.

The Technology Bank formed the basis of the gap analysis relative to the mission capability requirements.

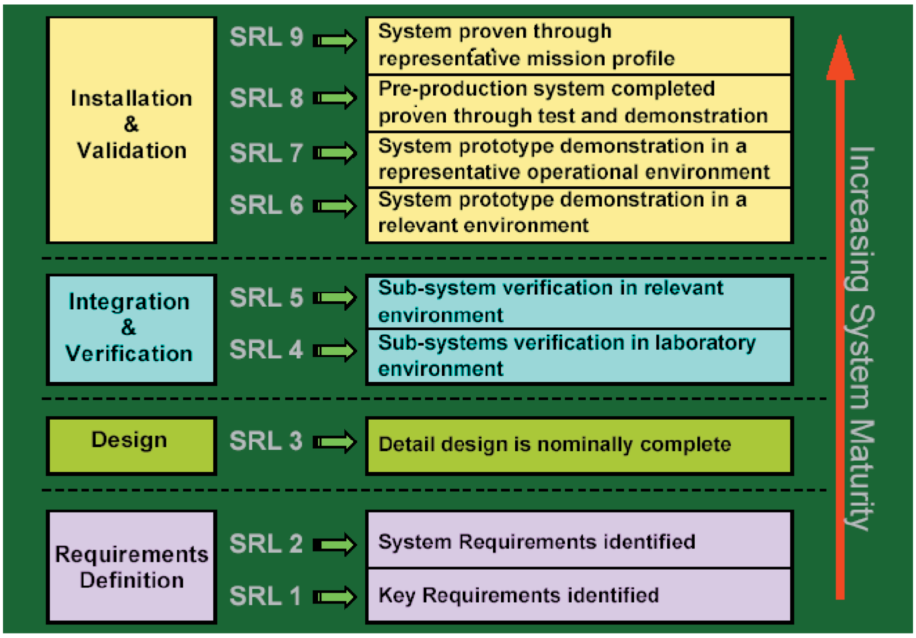

Figure 2. The System Integration Readiness Level (SRL) scale.

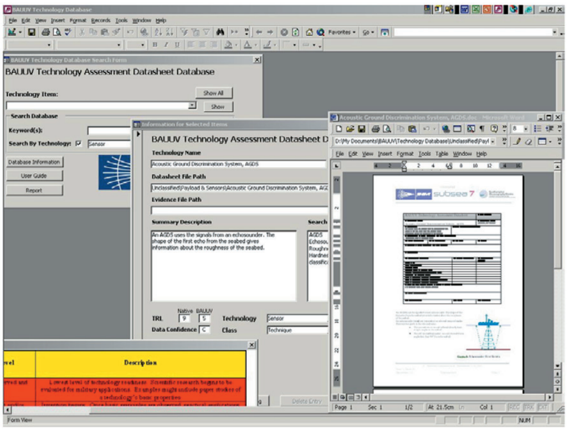

Figure 3. Technology Bank.

Technology gaps

The team's assessment concludes that while some UUV technologies are reaching maturity for many military commercial and scientific missions, there are significant gaps that need to be addressed before many of the MCS missions could be achieved. Key challenges include:

- collision/obstacle avoidance sensors
- autonomy to support flexible, long endurance military missions – including obstacle avoidance/escape logic
- reliable launch and recovery systems for current and future military platforms
- energy storage solutions
- specialist sensors, payloads and data processing solutions to support cover military missions
- robust and covert modular UUV designs
- covert end-to-end communications

Following a formalised BoI process, SEA has placed approximately 14 contracts to address these gap areas. A number of these projects will come to a conclusion by early 2005.

A new technology, BAUUV for the future, requires new techniques and thus the team aims to develop innovative ideas for the future BAUUV.

System options

The architecture options assessment has considered the concepts on which different technologies can be employed, based on the requirements outlined in the Mission Capability Statement. A range of concept envelopes have been developed including simple torpedo sections, low drag envelope, large bodies and winged vehicles.

Electronic and computational designs, based on open architectural principles derived from a functional breakdown, have been examined. These have covered issues on control, power and self-diagnostics. Acoustic signature issues are considered against the headings of background noise, vehicle noise, active navigation equipment, active sensors and acoustic modems. Since the size of UUVs are probably going to be some three orders of magnitude smaller than host platforms, signature problems are not seen as being a high development priority at present although, as mission capabilities become more detailed, this may become an issue for some applications. The operation of onboard sensors presents the greatest threat to covert operations of the BAUUV with current technologies.

The development of the system options is supported by simulation models. The Concept model aims to support system trade-offs and provide a mechanism to align key mission outcomes with the technology performance data. The model focuses on defining energy, power, mass, volume and data budgets relating to a candidate BAUUV configuration and mission profile.

The Concept model is designed to be modular so that a mission profile can be executed using different architectural and subsystem definitions to support the optimal sizing of a BAUUV configuration. It uses inputs from a detailed mission profile run plan, and files of technical and performance data to calculate the budgets required to deliver the mission.

A dynamic simulator has been developed to act as test bed for the various CCMM algorithms developed under the project. The model includes the hydrodynamic behaviour of the BAUUV, as well as low-level control laws and provides a real-time and faster simulation.

A 3D visualisation capability has been developed for use in conjunction with the UUV dynamic model to display a selection of important mission 'vignettes'. This uses vehicle motion vectors created by the dynamic simulator. It is used to illustrate ideas developed in the various technology development work packages, for example the obstacle avoidance sensors and CCMM projects.

As the overall requirement on UUVs is to add military worth, the project includes assessment of potential BAUUV effectiveness in appropriate scenarios. The Operational Effectiveness (OE) model is generally run in conjunction with the outputs of the Concept model. However, not physically part of the Concept model, the OE model can also be run independently to address particular issues.

The OE assessment considers both discrete events, such as collision, mine neutralisation or attack, and cumulative effects incurred either through repetition of actions or those that accumulate over time. Furthermore, the model has sufficient flexibility to handle the probability of success for events that do, or do not, affect subsequent events. The OE model can thus be programmed in sufficient detail to demonstrate cumulative probabilities of effectiveness over the duration of a mission or even an entire campaign. The OE model provides a ready tool to assess the effectiveness of UUVs relative to current assets and thereby quantify the operational advantages offered.

Exploitation route

The BAUUV Technology Bank provides a ready route for exploitation of the technologies captured therein to the MoD. Early drafts of the technology bank are already in use at the MoD. In addition, each technology developed under the BAUUV programme identifies an exploitation route in the commercial marketplace. A number of the technologies, including sensors and elements of autonomy, will have cross-domain exploitation opportunities in above water applications.

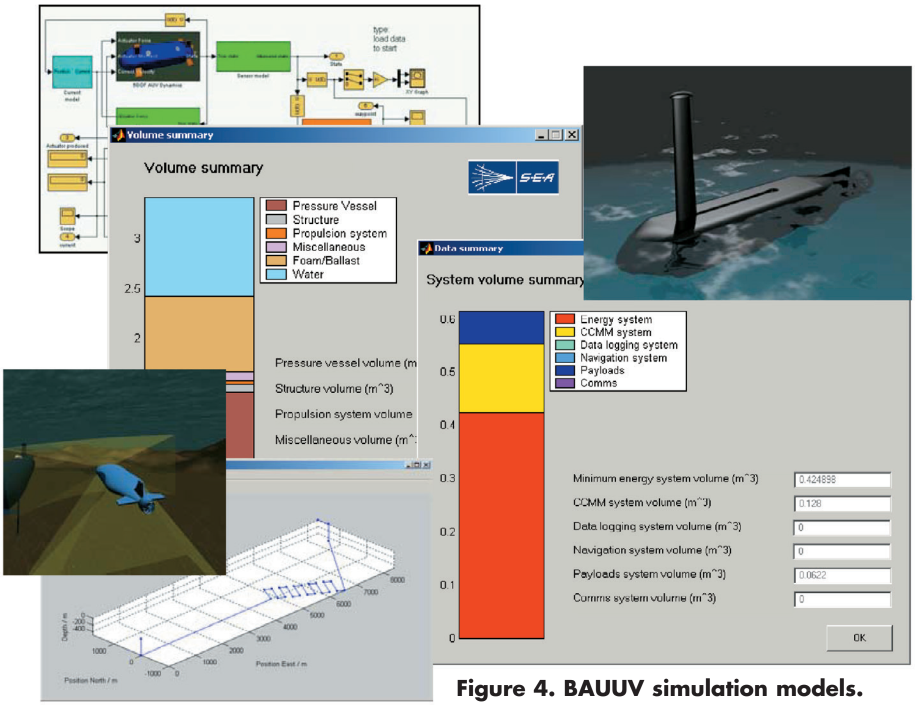

Figure 4. BAUUV simulation models.

An Implementation Plan defines the route for the procurement of a BAUUV prototype and fleet, consistent with the MoD's strategies. The team contributing to and consulted by the BAUUV project forms the basis of the industrial infrastructure to bring to fruition this exciting new technology for an enhanced future military capability.

The project will thus identify and de-risk the component technologies for future BAUUV and, through the integrated system trials, demonstrate the readiness of the developed technologies for exploitation by the MoD. ■