Simulation Based Acquisition: The Ground Truth

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Abstract. In the UK, the term Synthetic Environment (SE) extends conventional Modelling and Simulation (M&S) by 'link(ing) a combination of models, simulations, people or real equipment into a common representation of the world'. The integration of SE into the UK Ministry of Defence (MoD) acquisition process is known as Synthetic Environment Based Acquisition (SeBA) and is defined as the 'consistent and coherent application of modelling, simulation and SE technology within, and across, both acquisition phases and programmes to facilitate the attainment of the Smart Acquisition goals of faster, cheaper, better'. The SeBA concept is akin to the US vision for Simulation Based Acquisition (SBA). It is based on the application and management of a knowledge base, with an information repository shared amongst the stakeholders, but it extends through the life of a programme from capability gap analysis through to equipment disposal.

Government and industry share the vision for SBA and SeBA; the concept has been discussed at length at the conference circuit and is generally accepted by the acquisition community (interpretation of the terms vary widely!). It is believed that much of the SeBA-enabling technology is here today and the processes have been defined, but has SBA/SeBA really had any impact to date? This paper will summarise the UK's four-year collaborative (MoD/industry) research programme into SeBA, and will conclude by discussing the issues concerned with the full implementation of SBA/SeBA.

1. INTRODUCTION

Throughout this paper the terms Synthetic Environment Based Acquisition (SeBA) and Simulation Based Acquisition (SBA) will be used interchangeably. This is deliberate, since the authors believe that these two terms should be regarded as being synonymous. The fact remains that different readers will have different preconceptions concerning SBA, each will apply their own perspective on where it fits into the acquisition lifecycle. This paper presents the personal views of the authors; these views do not represent an official UK Government position or policy.

2. SeBA METHODOLOGY

The theory behind SBA has been extolled and articulated in many forums. In order to set the context for the thoughts and postulations later in this paper, the UK understanding is explained.

The SeBA approach begins at the initiation of the Defence Equipment Capability decision-making process, following the assessment of operational capability gaps, with the undertaking of trade-off studies to identify the possible equipment solutions. SeBA then facilitates the spiral development of the equipment 'solution' by using integrated models and simulations, increasing in fidelity, as a risk reduction mechanism in support of the acquisition programme. Throughout, the SeBA approach allows the key parameters of Performance, Cost and Time to be concurrently de-risked and optimised.

All the information used and derived through the SeBA approach is held within a central Knowledge Repository, which may take the form of a Shared Data Environment (SDE) or Advanced Collaborative Environment (ACE) and is accessible by all stakeholders but partitioned to protect national security and commercial sensitivities. With the use of suitable configuration control, a data audit trail can be achieved and the components of decision-making traced. This information sharing is essential in supporting the aims of defence acquisition. It provides a common infrastructure for the management and control of information flow between members of the enterprise, their resources and tools, via the implementation of appropriate process (e.g. system engineering). It facilitates the management of resources and tools, such as the potentially large numbers of integrated models and simulations and their associated volumes of data.

It can be seen that SeBA is predominantly concerned with the construction and management of an evolving set of Synthetic Environments (SEs), Models and Simulations (SEMS), of increasing complexity. The aim is to mitigate programme risk by simulating, modelling and emulating the necessary variables to ensure the equipment target remains within the specified boundaries (ordinarily of time, cost and performance). In an ideal implementation, everything would be known about the project and the equipment solution before any commercial commitment is made; this is unrealistic, as the expenditure to make this
assessment would normally outweigh the potential benefits.

Spiral development delivers an increasingly more detailed concept design, which requires more detailed analysis to support acquisition decisions. Within the 'SeBA wheel', see Figure 1, the inner wheel is 'spun' quickly; possibly many times for each step progression around the outer wheel, which represents the phases of the acquisition process. For each iteration, the inner wheel evolves and increases the fidelity of the knowledge appertaining to a solution; this knowledge is captured in the expanding central Knowledge Repository.

**Figure 1:** The 'SeBA Wheel'

In reality, the inner wheel is not a set of models polled sequentially. The models may be polled in any order and should only be called upon if they have something to contribute to the de-risking of the programme. There are many models that can be called upon, and those detailed are far from exhaustive.

Throughout spiral development, the central Knowledge Repository will continue to expand and therefore the architecture must be appropriately structured and the content managed. Clearly, since the repository will include highly sensitive information, like Operational Effectiveness (OE) predictions and commercially sensitive data, acceptable access and configuration controls are required.

The information gleaned at any stage is not only the springboard for the next phase, but must also form the audit trail to show why the project has arrived at a particular point. This audit trail is also essential when, inevitably, something upstream is changed and the project has to revisit earlier assumptions. Equally, data from the in-service phase needs to be captured, both for ongoing OE assessments and for re-calibrating the models and simulations used.

The management of the evolving models, simulations and SEs presents a challenge, and it is useful to distinguish between ownership and day-to-day management. The ownership should reside with the equipment or process specifiers, thereby enabling a degree of policing to be applied whilst retaining the responsibility for ensuring that it is compatible with the higher levels of political direction. Day to day management should be passed to the user or equipment procurer as appropriate.

Ultimately it is envisaged that there will be many stakeholders that own models or simulations that contribute to the SeBA process. Appropriate verification and validation processes will therefore be required to work in this context.

### 3. UK SeBA Research

The Synthetic Environment Based Acquisition (SeBA) Corporate Research Programme (CRP) was instigated as a 4-year Beacon initiative, 50/50 funding between UK government and industry partners, in Apr 98 and the activity completes in Jul 02.

**Figure 2:** Staged research programme

As well as examining the concepts and theories behind SBA, the research has undertaken Worked Examples (WEs) to mimic real acquisition programmes. The WEs have concentrated on the early part of the acquisition lifecycle and are not yet complete. It is hoped that they will effectively validate the SeBA guidance produced during the theory phase in 98/99 and highlight any weaknesses or conflicts in the information. This is an essential activity in order to ensure the available guidance is relevant and credible.

SeBA necessitates the construction of a M&S toolset which will vary in complexity as the project matures and this necessitates the introduction of an evolving Verification and Validation (V&V) process. This process needs to be developed to handle the potential problems induced by connecting models and simulations from different sources; it is envisaged that candidate equipment models as well as environmental and external system models will be provided by industry. Tensions associated with commercial and Intellectual Property Rights (IPR) and the need for the MoD government to be assured of the validity of commercial models also need to be alleviated. The development of an evolving V&V process and framework to support SeBA is being undertaken in collaboration with the French...
MoD and this research is scheduled to complete in Jul 03.

The cost-effective application of M&S within acquisition processes is not fully understood and has never been properly articulated. It is often taken as given or seen as a 'no-brainer', however, real evidence needs to be documented and a business case presented. The UK research programme is developing process models to assist in the identification of appropriate roles for SEs within the overall defence process and examining existing and new projects to determine and measure the cost-effective application of SEs. The results are looking promising but are, once again, built more on a conceptual model than facts and figures drawn from experience.

4. SeBA IN ACTION

In parallel with the research activities, several UK acquisition programmes are acting as pathfinders for SeBA and the lessons learnt are being captured and disseminated.

4.1.1 Future Offensive Air System

The Future Offensive Air System (FOAS) programme is developing an air capability to succeed that provided by Tornado, it must have sufficient flexibility to be capable of operating as part of a national or coalition force in operations ranging from peace support to major regional conflict. At this early stage of the project, knowledge and confidence in novel technologies is not high and concepts of operations (CONOPS) for future generations of manned aircraft, unmanned aircraft and cruise missiles have still to be developed. Using SEs early in the project allows initial analysis of concepts, force mixes and integration with other assets to take place prior to committing substantial funds during the Assessment Phase. The FOAS SE was initiated to provide data to aid this analysis, as well as providing proof of the benefits of the early use of SEs within the FOAS project. The analysis of the results is ongoing but there is sufficient confidence to ensure that SEs and SDEs will continue to be used and evolved to support the assessment and development of solutions in a common and coherent environment throughout the life of the project.

Figure 3: FOAS capability 'family'

4.1.2 Future Attack Submarine

The Future Attack Submarine (FASM) team has developed a through life modelling and simulation policy. This is being applied across all engineering disciplines to support a 'whole submarine' systems engineering approach, covering the complete life cycle (concept to disposal) and aims to realise the potential of re-use and enabling the smooth migration from concept modelling to the submarine firmware. The programme is still in its infancy but the investment in a flexible architecture at the onset of the programme should enable the project to embrace the principles of SeBA in due course.

4.1.3 Joint Strike Fighter

The UK is a major partner in the Joint Strike Fighter (JSF) programme and JSF's role in developing the UK's understanding, and indeed the world's understanding, of SBA cannot be ignored. In 1994, the then JSF programme manager, Gen MUELLNER, indicated an intention to use an unprecedented level of M&S. He saw the technology as providing the means to:

- Facilitate fully developed & validated operational requirements.
- Integrate team of users and developers.
- Conduct trade-off analyses of critical user defined performance parameters using unprecedented levels of joint analyses and simulation.
- Evolve requirements over time.
- Reduce future strike systems development, procurement, and support costs.

Today, the stated vision is to integrate JSF program disciplines, both within and between government and industry, through collaborative use of M&S capabilities and to develop a robust simulation environment for use throughout all phases of the JSF program, and for other DoD and US/Coalition programs.

Without doubt, the early ‘mandation’ of M&S, together with consistent funding, has enabled SBA to be seen as a significant facilitator in the programme. SBA is listed as one of the significant contributors to the saving of one flying prototype. At the National Defence Industries Association SBA conference in Jun 01, Mr. Frank CAPPuccio, vice president JSF, Lockheed Martin Corporation, said that the company had 'achieved a 50 plus percent reduction in acquisition cycle time and cost via M&S, and the savings have been incorporated into our proposal bid'.
As the JSF programme continues, a manta has been placed: every live hardware or component trial, including flying, has to be justified as to why M&S is not being used in lieu. M&S is seen as the norm!

5. AND IN THE REAL WORLD…

Until now, this paper had concentrated on the theory and practice. As a health warning, this is all somewhat idealised and could be said to be the ‘party line’ for SBA. In truth, there are many barriers preventing the full exploitation of the technology within acquisition.

5.1 What’s in a name?

The first problem is the title ‘Simulation Based Acquisition’. Whilst the term ‘Simulation’ is understood internationally, and this has been substituted by Synthetic Environment in the UK, let the problems begin.

‘Based’ implies taking over other initiatives and with SBA being ‘the only one-way’ and the single one—initiative within the totality of acquisition reform. In practice, if SBA is to be introduced, it will never be a ‘big bang’; evolution not revolution is required. SBA is dependent on acquisition reform and it is more than just the use of M&S, at its cornerstones are SDEs/ACEs and the all too prevalent and catch all backdrop of System Engineering.

Ask someone to define ‘Acquisition’ and you will get a different story depending on his or her viewpoint. In the UK, the official government definition implies ‘lust to dust’ equipment lifecycle management. In the US, the term is a lot narrower covering the project management phase associated directly with equipment procurement; it does not generally cover capability/requirements analysis or In-Service support/logistics phases of the equipment lifecycle. This disparity is then compounded by viewpoints. The Test and Evaluation (T&E) community may claim to be undertaking SBA within a programme, and indeed they may be using a great deal of M&S, but does one user or community make it an SBA programme? There is a natural tendency for some projects, and more particularly project managers, to use the latest acquisition philosophy as a lever to gain notoriety and ‘ring fence’ their funding. SBA must cut across the whole project, it has to be a conscientious decision and go hand in hand with other related, modern and innovative acquisition techniques.

5.2 So what is SBA really about?

There are many definitions for SBA. There are some succinct one-liners but most statements are visions and these have been produced on departmental or area specific lines. Rather than developing a single sentence, it is believed that SBA should endorse and cover a range of points including:

- Application of Advanced Information Technology.
- Comprehensive functional assessments to reduce risk and make better-informed decisions.
- Early optimisation and trades between system performance and total ownership costs.
- Minimisation of costs through standards-based reuse of information and software.
- Optimal program investments by consideration of system of systems.
- The use of enduring collaborative environments with reusable, interoperable tools and supporting resources.
- The automated near real-time sharing of relevant information among all personnel (distributed product description) through a common technical architecture and open, commercial, data interchange standards.

5.3 Policy and leadership

In order to make a difference, and for an initiative to be accepted, high-level support is required. Undoubtedly, the USA has led the international SBA activities. Arguably, SBA evolved from the US DoD (Dr Pat Saunders' office) in 1996 with the quest to exploit M&S in the acquisition field, prior to then its use had only been acknowledged in the training and analysis fields. For many of the intervening years there has been no central DoD drive for SBA, the current DoD-level acquisition reforms do not include SBA as a cornerstone activity and this has lead to the individual US services following their own paths. That said, the US have amended their acquisition regulations (5000 series) to recognise the term SBA in addition to more general M&S. However, there appears to be a significant shortfall in SBA-related guidance provided to programme managers. Ordinarily the 5000 series contains a full glossary of terms. Apparently SBA is not included in the glossary.
because the words cannot be agreed and the only definition is embedded in 5000.2: ‘SBA is the robust and interactive use of M&S throughout the product lifecycle’. It is normal for the 5000 series guidance to be supported by formal documentation and best practice information, however, this is not the case in SBA. There has been a lot of informal literature produced by the ‘community’ but none of it has official standing, there is a distinct lack of authoritative signatures on the bottom of documentation to give it official DoD standing. In order to drive changes and bring people with different perspectives together, a SBA ‘czar’ and focal point is needed. Goals and targets can then be agreed and common expectations defined, even if viewed from different perspectives.

The US Army has developed Simulation and Modeling for Acquisition, Requirements and Training (SMART) and this is, without doubt, the most advanced, well-funded and touted SBA programme. SMART aims to cover the majority of the lifecycle from Requirements to Logistics. The programme is well supported by the Army hierarchy and the Apr 02 SMART Conference, attracted keynote speakers from the very top of the Army command structure and the most influential acquisition programme managers. It is evident that SMART is no longer focussed on the use of M&S but has evolved to embrace the use of advanced information technology as a whole.

In parallel with the UK experience, the DoD level US acquisition cycle has also evolved in parallel with the SBA 'initiatives' leaving much of the SBA documentation to rapidly date. Almost fortuitously, the apparent need to invent a new defence acquisition cycle every so often has benefited SMART. It has managed to place itself at the fore of the acquisition reforms and therefore the title of M&S is carried as a banner although SMART is far more than just this one technology.

5.4 Technology
Many of the documents and presentations associated with SBA concentrate on the key areas of Process (iterative acquisition process), Culture (evolved acquisition culture) and Environment (integrated advanced engineering and enterprise). There is little mention of M&S itself and technology in general, or indeed how they should be applied. Attention has been focussed on the acquisition process itself and not on how to support it using M&S technology.

Whilst SBA started as a M&S initiative, the title now encompasses a broad spectrum of advanced technologies including Computer Aided Design (CAD), Computer Aided Manufacturing (CAM), automated logistics, embedded training and, at its heart, SDEs and ACEs. All of these technologies exist on their own, and many have provided support to the acquisition lifecycle for years; SBA has the desire to exploit them and use IT interoperability to bring value that is greater than the sum of the parts. The ideal SBA programme is not one that uses a single large networked environment, but the programme will call upon the complete spectrum of advanced information technology.

5.5 Industry involvement
It is interesting to note that, in the main, SBA has been developed and discussed within government. Whilst industry has been involved, it has been almost as an insurance policy to ensure that they are at the front of an initiative if it does hit 'mainstream'. This government dominance has lead to concepts and ideas that are effectively meddling in the contractor's business. The current 'gain-share' and 'win-win' mentalities blur the boundaries between government and industry interests, but the boundaries should still exist. Government program managers and scientists should not be delving in to the details of the factory design and workflow. Whilst such issues can be modelled and do form part of the total considerations, the government should focus on the Operational Effectiveness issues. If delivery schedule is an issue, industry can then use the technology to investigate solutions and suggest alternatives. If necessary, interfaces can be built to the 'top level' OE models but permanent links should not be the norm.

When talking with 'uninitiated' industry, SBA is taken to mean CAD/CAM and basic engineering. They would argue they have been doing it for years citing the example of CATIA as natural evolution and the current 'state of the art'. Whilst this is true in their microcosm, it does not help form the partnership that governments are looking for. With the increased stretch in budgets, decision-makers need to understand the system as a whole, including all its influences, even if that is the small widget being manufactured in a production line. Such decision-makers are not individuals but teams that work within the ACE.
At the end of the day, without government intervention market forces will prevail, industry will implement whatever new technology and processes it deems necessary to guarantee return to its shareholders. SBA is all about partnerships and collaborative working, and therefore industry needs to be involved and understand where the benefits for them are coming from. The government needs to drive this partnership but with due consideration for Intellectual Property Rights (IPR), corporate advantage needs to be maintained if a company is to remain successful. Government will always own the M&S environment into which industry interfaces. This environment needs to be validated and responsibility for its content and performance duly accepted by the government project.

5.6 Education and Training

As in many fields of life, education can be the key to success. Training a workforce to accept technology and exploit it is a difficult and time-consuming task, but one that is necessary to ensure a successful SBA programme. The project manager needs to understand the available technology and then be able to assure himself that he is using it to the correct level without prejudicing integrity. The engineer and designer needs to have a sufficient understanding of project management to pass up the relevant information. Education and training for SBA therefore crosses both technical and managerial skills. The ACEs require management and specific skills training in order to exploit them to the maximum. Without training a workforce for these tasks, the investment will be worthless.

5.7 And there are more…

Whilst SBA does, necessarily, ‘front-load’ a programme to gain the benefits downstream, there is a distinct danger of trying to do too much up-front. Deciding just how much M&S to do up-front is one of the key management judgements to be made. In order to step forward and reap the anticipated rewards, risks do need to be taken. SBA and the use of M&S can help identify many of these risks but identification of all the risks, together with their mitigation, would be so lengthy that the equipment would never be delivered.

SBA requires a different spending profile. Setting up the environments and toolsets requires a significant up-front expenditure; this funding is notoriously difficult to obtain. Central support and budgeting could help, however, there is natural reluctance as this expenditure is required before the first acquisition breakpoint and the risk of project cancellation is high. The reuse of M&S components can significantly save money, however, project managers are naturally reluctant to spend the delta between their specific product and the generic, reusable, version out of their project funding. Central fiscal support in such issues could reap significant long-term savings.

Within acquisition as a whole, there are many different interested parties from the Operational Analysts to the Acceptance community. Despite the concept of Integrated Project Teams, each of these areas operates as separate entities with their own procedures and M&S assets. As long as one area has not embraced the concept, the chain is broken and the value and rewards of SBA cannot be obtained.

6. CONCLUSIONS

SBA has evolved in a very ad-hoc manner but the theory and methodologies have been researched and documented. The US Army SMART programme has fully embraced the principles of SBA, but this is predicated on much more than M&S, it is the exploitation of advanced technologies as a whole.

It is believed that SBA is an initiative that will significantly influence future acquisition but larger acquisition initiatives that are ‘driven from the top’ will always take precedence. SBA has already been a catalyst for acquisition reform and, given technology take-up trends, in 3 to 5 years the dust will be blown off the conference papers and the SBA visionaries will be praised. The success of SBA should not be measured by the frequency of the use of the term in programme plans. SBA will have succeeded only when the principles behind it are embraced in acquisition reforms and SBA will then not be seen as something different, it will be when it becomes—an organic part of acquisition itself and the term ‘SBA’ will have long since faded. Then, and only then, you will hear a cheer from this corner of the UK.