<u>"The Technical Challenges of Implementing SBA"</u>
<u>presented by Nicholas Wrobel</u>
<u>at the SBA Conference in London on 1-2 March 2000</u>

1. Introduction

This paper describes the *technical* challenges of implementing SBA **at the enterprise level** across the **whole of the Acquisition lifecycle**.

To gain such a high-level perspective, this paper invites the reader to take the 'high ground' and set aside for the moment:

- the benefits & investment costs (since these are covered in other papers); and
- the lower level, detailed issues that are being addressed on a day-to-day basis.

2. Aims

The aims of this paper are to:

- review very quickly the technical challenges in Simulation & Acquisition over the last 25 years to gain a historical perspective on those facing us today
- postulate the current requirements for SBA
- identify the issues arising from these requirements, the solutions that address these issues and the problem areas remaining.

Examples are used to demonstrate the best solution in each of the major phases of the Acquisition process.

3. Historical Review of Simulation & Acquisition

Since the term "Acquisition" may be used differently throughout this Conference, it is worth stating that it has been used here in its **broadest** sense; namely, covering the Whole Life Process of a product from R&D to decision-making, build, operational use, maintenance, (pre-planned) mid-life improvement & disposal. It will be shown that Acquisition is **currently** <u>Open Loop</u> throughout most of the Whole Life process.

Similarly, the term "Simulation" will also be used here in its broadest sense; namely, the use of computer-based models representing physical systems, human interaction, group behaviour and large-scale military forces.

Mathematical modelling has advanced significantly over the last 25 years with the advent of powerful & affordable computers - now available even on the desktop. In many cases, computer-based models - which historically ran much slower than realtime - now run many times faster than realtime. Similarly, measurement & validation techniques have improved giving a better understanding of the accuracy & applicability of computer-based models.

These advances have enabled hardware to be tested in-the-loop and simulators to be produced with men in-the-loop. The level of task & workload realism within these simulators has increased dramatically with the emergence of realtime visual systems that present high fidelity out-the-window views.

Finally, the advent of Distributed Interactive Simulation (and more recently HLA) has enabled the linking of *distributed* manned simulators & computer-generated forces to examine technical & operational usage issues with realtime interaction.

Acquisition in the last 25 years has migrated from the replication of the 1-man teams (characterised by Mitchell developing the Spitfire) to the formation of a multitude of specialist groups with highly-focussed skills. The latter have championed technologies such as CAD, finite element analysis & computational fluid dynamics.

Today, the goal in Acquisition is to **integrate** project teams - comprising *geographically-separated* managers, specialists, users & support staff - *over the whole lifecycle* of a project. The key question is "How is this to be achieved in a cost-effective manner"?

4. Requirements for SBA

SBA is a catch-all term that could easily become the "buzzword" for specialists (& indeed others) to justify ever bigger & faster models, computers, visual systems, networks etc. It is not difficult to find examples of visionary statements made over the last 25 years which have been quickly hijacked & gone off the rails.

The author's view is that SBA is a **"tool"** to aid the Acquisition of a product - it is not an end in itself and we must keep reminding ourselves of this or SBA will disappear even more quickly than it emerged. SBA needs a framework in which to operate and requirements to give it direction.

In order to postulate the requirements for SBA, let us reflect on the earlier statement that Acquisition involves the Whole Life Process from R&D to disposal. We are all comfortable with the construction of a **prototype** to enable early usage & reduce risk. We may even invite End User participation - in a limited manner - in order to assist in the production of the acceptance specification or to influence the acceptance tests that will be undertaken much later.

We are all familiar with the use of a cockpit Simulator for this purpose to sort out the MMI & crew workload etc. If that simulator were to be **Reconfigurable** (see Figure 1), then it could be used much earlier in the Whole Life process - say, in the Design & Development to ensure that the solution is robust to the currently intended usage.

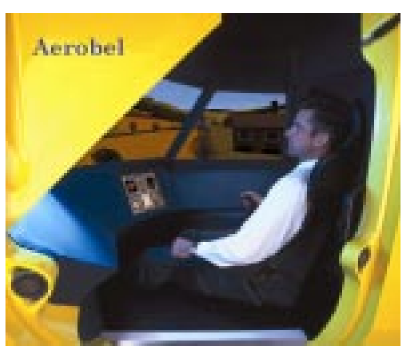

Figure 1 - New Breed of Reconfigurable Simulators

More daringly, if the End User's tactics are still evolving, such low cost simulators could be used to develop these tactics at a much earlier stage of the lifecycle. Similarly, they could be used to generate cumulative sortie profiles in simulated out-of-area operations to ensure that the logistics train can maintain the product *in the field.*

The inescapable conclusion is that we must **close the loop** <u>throughou</u>t the whole Acquisition process - not just in selective parts. Hence the current requirements of SBA are as follows:
a) enable the End User to be involved <u>much earlier</u> in the Whole Life process with men in-the-loop;
b) provide closure of-the-loop <u>throughout</u> the Whole Life process; and
c) facilitate collaborative working <u>throughout</u> the Whole Life process.

This can be summarised as putting the Whole Life Team **<u>in-the-loop</u>**.

5. Issues, Solutions & Problem Areas

<u>5.1 Issues</u>

From the 'high ground', it is clear that SBA will only flourish as a "tool" to aid Acquisition *if* it becomes widely accessible. Without this, it will continue to be perceived as a *niche area* for specialists.

To meet the requirements above, we need to:
a) find/formulate a framework which provides **access to** & **integrates** existing design tools, simulation models, cost models, OA models etc to address the Team's issues at all levels across the Whole Life; and
b) gain experience & evolve this framework to address in a cost-effective manner the Team's issues at all levels across the Whole Life.

Enabling technologies that *might* provide such a framework include:
- Simulation
- Concurrent Engineering (CE)
- Collaborative Virtual Product Development (CVPD) *.

* As many readers will be unfamiliar with CVPD, it is worth summarising this new enabling technology. CVPD is <u>realtime collaboration</u> in the digital prototyping, visualisation & evaluation of products in a simulated high fidelity 3D SE. It is a framework that sits above an organisation's existing IT facilities (eg CAD, Sim & Modelling, PDM, Costing, ILS etc) and enables <u>controlled sharing and re-use of data & knowledge</u>.

CVPD is now available via COTS software tools running on PCs and using the internet. These tools are <u>modular & scalable</u> for enterprise-wide deployment. One of the main benefits of CVPD is that it provides <u>access on the desktop</u> to multiple sources of data thereby bringing together Whole Life Teams and breaking down the 'niche' label of SBA.

<u>5.2 Solutions</u>

Comparing each of these enabling technologies with the requirements for SBA, it can be seen from Figure 2 that Simulation meets the 1st requirement but it does <u>not</u> provide closure of the loop and facilitate collaborative working throughout the Whole Life process.

Requirements	Enabling Technology		
	Sim	CE	CVPD
End User involved much earlier in the Whole Life Process with Men in-the-loop	✓	×	✓
Closure of the Loop throughout the Whole Life Process	×	×	✓
Collaborative Working throughout the Whole Life Process	×	×	✓

Figure 2 - Comparison of Enabling Technologies with the Requirements for SBA

Concurrent Engineering is generally stand-alone & serial and information flow is not well coordinated. Therefore, it does not appear to meet any of the SBA requirements.

CVPD meets all 3 SBA requirements as will be demonstrated in a series of examples which show closure of-the-loop in each of the major phases in the Whole Life process. These examples have been undertaken by Aerobel using a COTS CVPD toolset called PIVOTAL™ by Centric Software *.

* PIVOTAL™ runs on PCs and it imports CAD data directly. It enables behaviours such as animation to be added to 3D components and it has powerful tools called 'data probes' for linking the latter to 'live' data, simulation models, cost models & databases.

PIVOTAL™ has a Microsoft-like GUI, it is web-enabled and it is fully-compatible with Microsoft's Office products. It includes project management support for control of access, process flows & audit trails. In summary, it provides easy but controlled access to, viewing of & interaction with multiple sources of data on the desktop.

Firstly, let us look at a concept for the future recce vehicle - Tracer (see Figure 3) to examine a **design & development issue**. In this example, the End User is not confident that, with the proposed mast height, the vehicle will be able to operate successfully in typical out-of-area operations. By importing the Tracer CAD model & a suitable terrain database directly into the CVPD tool on the User's PC, the latter can check the typical lines of sight with the mast elevated. A semi-quantitative assessment can be done in a few hours.

Figure 3 - User examining the Effect of Varying the Mast Height of Tracer

Secondly, let us look at a concept for the future carrier - CVF (see Figure 4) to examine a **high-level decision-making issue**. In this example, the End User is not confident that, with the flight decks & lifts proposed in different concepts, the platform will be able to operate satisfactorily under typical conditions. By importing the CVF & aircraft CAD models directly into the CVPD tool on the User's PC and linking them to a suitable computer model (typically running at a different site), the User can check the **number of aircraft sorties in a typical 24 hour period**. A quantitative assessment can be done in a few days.

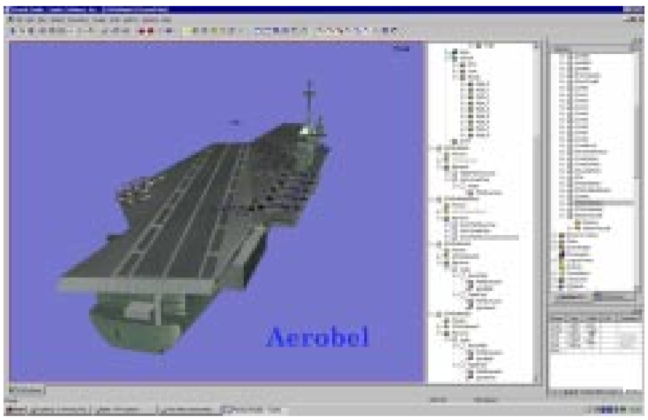

Figure 4 - User examining the Number of Sorties within a 24 hour period for CVF

Thirdly, let us look at this same concept for the future carrier - CVF (see Figure 5) to examine a **build/prototype issue**. In this example, the End User is not confident that, with the lower deck layout & lifts proposed, aircraft can be brought safely onto the flight deck in a given timescale. By importing the CVF & aircraft CAD models directly into the CVPD tool and animating the aircraft, the User can check the fit & time taken to move aircraft safely onto the flight deck. A quantitative assessment can be done in a few hours.

Figure 5 - User examining Aircraft Fit & Movements to Flight Deck for CVF

Fourthly, let us look at the concept for the future LIght Mobile Artillery Weapon System - LIMAWS (see Figure 6) to examine a **usage & tactics development issue**. In this example, the End User is not confident that, with the configuration proposed, the artillery system can be re-deployed in a given timescale <u>if</u> a shoot-&-scoot tactic were to be adopted in the future. *[Readers will forgive the author's use of an actual historical case here (in which he was indirectly involved) to illustrate a situation that could still happen today!].* By importing the platform & munition CAD models and a suitable terrain database <u>directly</u> into the CVPD tool and animating the key parts, the User can check - during the early part of the Acquisition lifecycle - the time taken to re-deploy to a new firing position. A semi-quantitative assessment can be done <u>in a few hours</u>.

Figure 6 - User examining the Effect of Changing Tactics for LIMAWS

Finally, let us look at an imaginary future scout car (see Figure 7) to examine a **maintenance issue**. In this example, the End User is not confident that, with the configuration currently proposed, key components (eg the front shock absorber) can be replaced in a given timescale *in the field*. By importing the vehicle CAD model <u>directly</u> into the CVPD tool and animating them in line with the proposed disassembly sequence, the User can check - during the design phase - the procedure & time taken to replace the key components.

A quantitative assessment can be done <u>in a few hours</u>. The User can also check the likely failure rate of these key components from ILS data on the previously-procured vehicle to determine the likely frequency of this procedure.

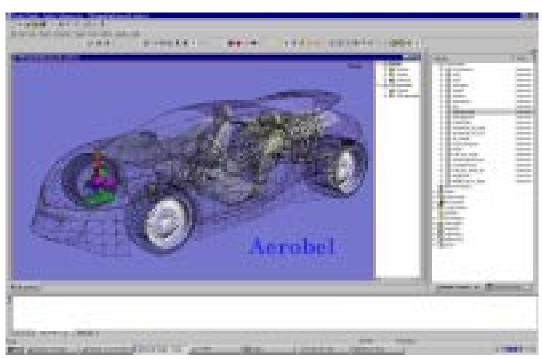

Figure 7 - User examining the Replacement of Key Components on the Future Scout Car

Traditionally, in all of these examples, the End User might acquire many months later (& at considerable cost) one of the following:

- an OA study with reams of statistical data
- an engineering study with lots of diagrams & figures
- results from a field trial (having built a costly physical prototype).

As individual issues, the poor timeliness and difficulty of assimilating the results produced using traditional methods often means that such studies/trials are ineffective, undervalued or not used at all. The outcome is low confidence that the End User's genuine concerns will be addressed in the procured product or the User finding out the actual situation after having bought the product!

At the programme level, the traditional sequential approach results in difficulties being found later in the lifecycle where a change is more costly and collective changes produce overruns which lead to cost escalation.

By reducing these difficulties, CVPD provides the 1st big step towards achieving "better, faster, cheaper".

5.3 Problem Areas

CVPD software tools address the technical challenge of putting the Whole Life Team in-the-loop (see Section 4). They empower the Whole Life Team with a **framework to enable SBA to be accessible and, therefore, become mainstream** - rather than remaining niche (see the 1st requirement in Section 5).

For SBA to be successful, the 2nd requirement also has to be met; namely, **experience must be gained to evolve this framework** to address in a cost-effective manner the Team's issues at all levels across the Whole Life.

Therefore, there are several problem areas that remain to be solved or quantified:

a) how the required changes in working practices can be accelerated
b) the level of authentication & encryption needed to use public networks for the transfer of this type of data
c) with such easy access to data, the convergence on a robust solution
d) the level of fidelity required for VV&A
e) the benefits versus the investment.

Whole Life Teams comprise managers, specialists, users & support staff located on widely dispersed sites over a period of typically 25 years. Most team members already have direct access to a PC and they are familiar with internet software (eg for sending text documents by e-mail). However, they are unfamiliar with **synchronous collaboration** - in which many people can view, discuss & annotate the same CAD models interactively with on-line pointers and animate/link CAD models to simulation/cost models & other data sources such as ILS databases. The slow adoption of CAD indicates that it will take many years to change current working practices unless accelerated by proactive measures.

Empowering users with CVPD could lead to 'best practice' or potentially to anarchy in the same way that modern CAD & graphics tools can lead to loss of configuration control because they enable users to modify 3D models very easily. In practice, as CAD systems have grown, PDM systems have been installed to manage the configuration control issues. CVPD does not change this - since the original source data is not revised - but the ability of many users to access data easily does present the risk of the Acquisition goalposts moving even more regularly! CVPD provides a framework for SBA. It is not a substitute for project control and disciplined systems engineering practices.

The level of fidelity required for VV&A will only be found as experience is gained with SBA. One of the most interesting capabilities in some of the COTS CVPD tools is the ability to modify **interactively** the fidelity of selected parts of the CAD model. This enables a user to see the <u>whole</u> system at lower fidelity and increase fidelity selectively to examine <u>specific</u> issues. This is shown in Figure 8 with the muzzle brake of a LIMAWS concept.

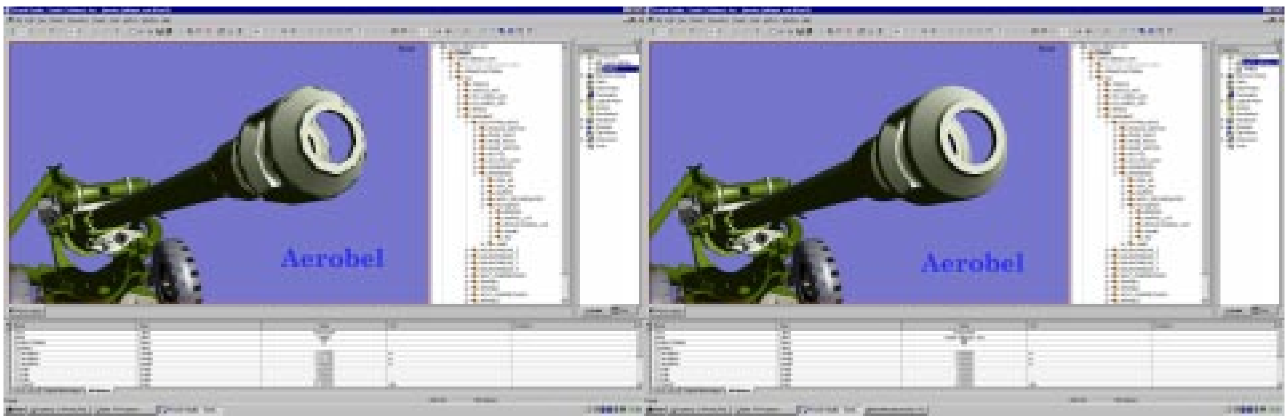

Figure 8 - Varying interactively the Fidelity of Selected Components of LIMAWS

The problem of acquiring reliable quantitative data to prove the benefits of SBA is outside the scope of this paper and it is being covered by other speakers at this Conference. However, there are good examples in the USA of **savings in travel costs** and **reduced acquisition timescales** with CVPD.

For example, Lockheed Martin Missiles & Fire-Control cite (Ref 1):
- a reduction in the design change cycle time of 50% on the US Army's line of sight anti-tank missile (LOSAT) programme
- a reduction in the (component) acquisition process time from 5-6 months to ~2.5 months.

Similarly, Rocketdyne found that (Ref 1):
- it saved $500k on travel through virtual co-location of the team on the RS-68 booster for the Delta IV programme
- the design process took about 10 times less than in a traditional co-located environment
- traditionally, there are 1500-3000 parts in an engine's combustor. This was reduced to just 92; with only 6 of these parts being unique to the design
- the development cycle time is expected to be reduced from 2 years to 1.

6. Summary

This paper has reviewed the *technical* challenges in Simulation & Acquisition over the last 25 years to gain a historical perspective on those facing us today. It has then postulated the current requirements for SBA. Finally, it has identified the issues arising from these requirements, the best solution that addresses these issues and the problem areas remaining.

The author has contended that SBA is a **"tool"** to aid Acquisition and it will only flourish if it becomes widely accessible. Without this, it will continue to be perceived as a *niche area* for specialists.

It has been postulated that the current requirements for SBA are to:

i) enable the End User to be involved <u>much earlier</u> in the Whole Life process with men in-the-loop;
ii) provide closure of the loop <u>throughout</u> the Whole Life process; and
iii) facilitate collaborative working <u>throughout</u> the Whole Life process.

These requirements can be summarised as putting the Whole Life Team **<u>in-the-loop</u>** and, in order to meet these requirements, we need to:

a) find/formulate a framework which provides **access to** & **integrates** existing design tools, simulation models, cost models, OA models etc to address the Team's at all levels issues across the Whole Life
b) gain experience & evolve this framework to address in a cost-effective manner the Team's issues at all levels across the Whole Life.

Enabling technologies that *might* provide such a framework include:

- Simulation
- Concurrent Engineering
- Collaborative Virtual Product Development (CVPD).

CVPD is the only solution that meets all 3 SBA requirements and a COTS CVPD toolset called PIVOTAL™ has been used to demonstrate closure of-the-loop in each of the major phases in the Whole Life process. These examples included:

- a concept for the future Tracer recce vehicle to examine a design & development issue
- a concept for the future carrier CVF to examine a high-level decision-making issue
- this same CVF concept to examine a build/prototype issue
- a concept for the future LIght Mobile Artillery Weapon System LIMAWS to examine a usage & tactics development issue
- an imaginary future scout car to examine a maintenance issue.

In conclusion, for SBA to be successful **at the enterprise level across the whole of the Acquisition lifecycle**, we must close the loop throughout the Whole Acquisition Life process and CVPD is the key enabling technology to achieve this.

<u>References:</u>

1 – Article by Michael Mecham in Aviation Week & Space Technology; December 1999

Profile of the Author

Nicholas graduated with a BSc(Hons) in Aeronautical Engineering at Southampton University in 1972 and, after 3 years postgraduate research into **pollution** using an advanced laser diagnostic technique, he joined the MoD within the Scientific Civil Service.

He was promoted to Principal Scientific Officer (Grade 7) at 30 and, over the next 4 years, he was:

- the MoD Project Officer for a novel weapon system Technology Demonstrator programme
- the Land Systems Project Officer for a major tri-service Countermeasures Project & the UK/US Working Party on Armoured Fighting Vehicle Survivability
- the Chairman of one of the sub-panels that coordinate the research work of the UK's R&D Establishments.

He joined CAP Scientific (now part of BAe) in late-1984 to create a **new** Land/Air Systems business group and, within less than 2 years, he was appointed Manager/Military Technology & Systems with over 25 professional staff. He directed projects spanning the study of gun-launched HVMs to the build of prototype robotic vehicle sub-systems and, from August 1986, he had a major involvement in the SDI UK Architecture Study.

In mid-1987, Nicholas formed Aerobel Defence Technology - a British IT-based engineering company - where he is the Managing Director.

Aerobel undertakes **systems engineering studies** & **software development** and a significant part of the company's business comes from the **non-defence sector**. Over the last 10 years, the company has become a leading provider in Europe of **interactive visual systems** for design and operational/training systems.

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