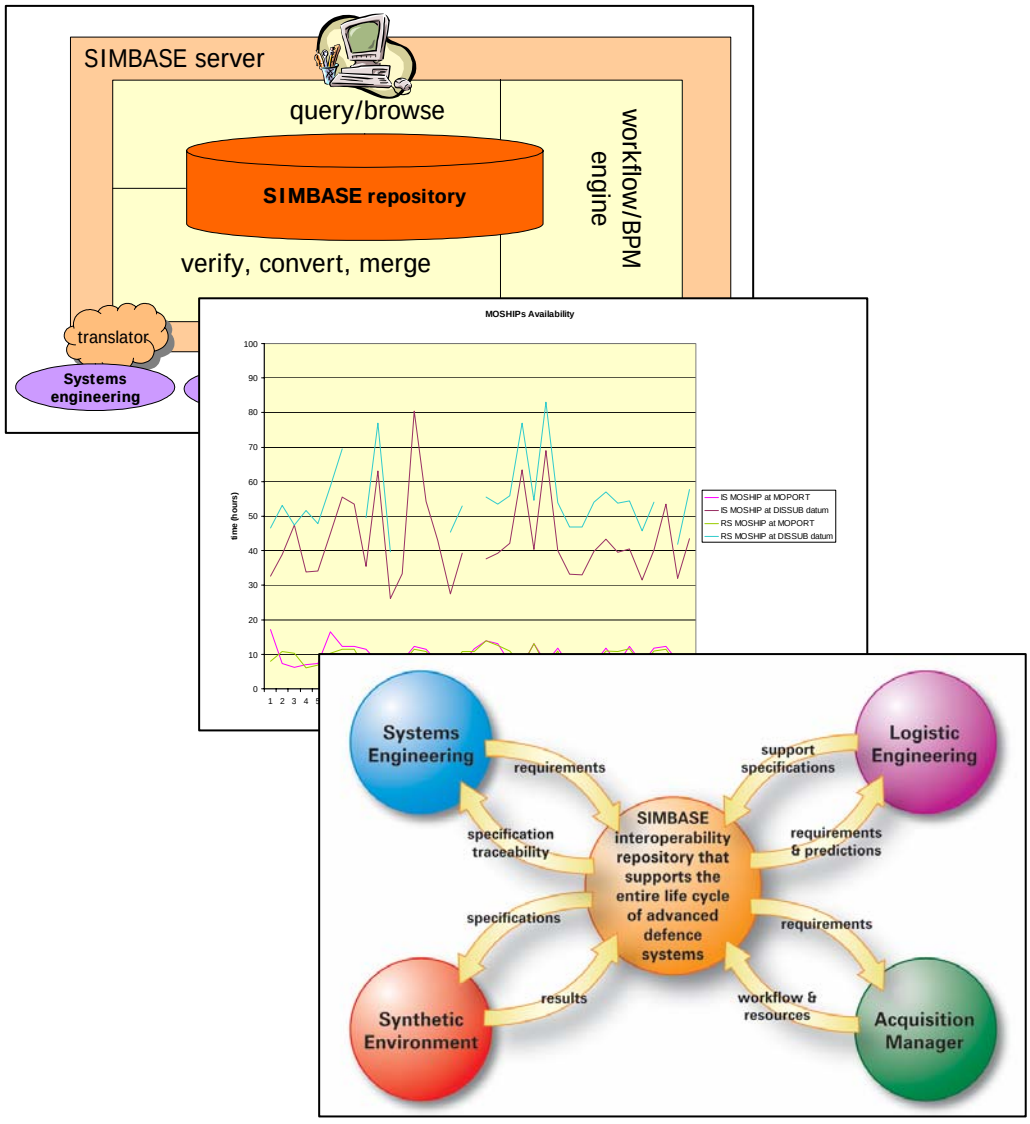
SIMBASE

http://www.simbase.info/



Project Executive Summary

SIMBASE PD09 Executive Summary – Issue 1.0

Details

Project contract		***Document reference***	
European Defence Agency, 04/111.011/06		WP010/025	
Document details		***Author contact details***	
Issue & iteration:	1.0	Name:	Dr. Timothy KING
Date:	2007-11-27	Organisation:	LSC Group
Document status*:	Approved by TAMG	Telephone:	+44-1543-446850
Information status**:	Foreground	e-mail:	tmk@lsc.co.uk

* Project participants shall only pass on the document to other organisations if the security classification is "Not protectively marked".

** except where explicitly marked otherwise. Existing Intellectual Property Rights reside in external documents in the case of included extracts from such documents.

Distribution		
EDA[1] Pascale HARDY Gregorio AMEYUGO	*TAMG*[2] Duncan ROGERS (UK) Arturo SALZANO (IT) Karsten BRÅTHEN (NO)	*For information* Neil SMITH (UK DSTL) Graeme HAWKINGS (UK MoD RAO)
Datamat Curzio BATINI Raffaella COLACI Daniela BRACCIOCURTI	*EPM Technology* Jochen HAENISCH Kjell BENGTSSON	*LSC Group* Tim KING Ann MEADS

Amendment record

Issue 1 – first issue.

1 European Defence Agency <http://www.eda.europa.eu/>.

2 Technical Arrangement Management Group.

1 Business context

Physical testing of complex systems is expensive, sometimes difficult in respect of extreme regions of the operating envelope (for example, attempting to sail prototype ships in stormy conditions) and can discover critical problems far too late in the development process. Thus, Ministries of Defence have identified the value of modelling and simulation techniques in a process known as either Synthetic Environment Based Acquisition (SeBA) or Simulation Based Acquisition (SBA) (SeBA/SBA).

In parallel to enhancing the acquisition process with modelling and simulation, organizations have also recognized the need for open approaches to the exchange, sharing and archiving of engineering data. To this end, these organizations have collaboratively developed a suite of product data standards. These standards enable an integration of organizations and processes, thus, avoiding costs and constraints in the extended enterprise.

The SIMBASE project has addressed the fundamental research question as to whether the modelling and simulation community should embrace product data standards as a necessary part of the infrastructure to make SeBA/SBA an effective and efficient enabler of acquisition [see **Figure 1**].

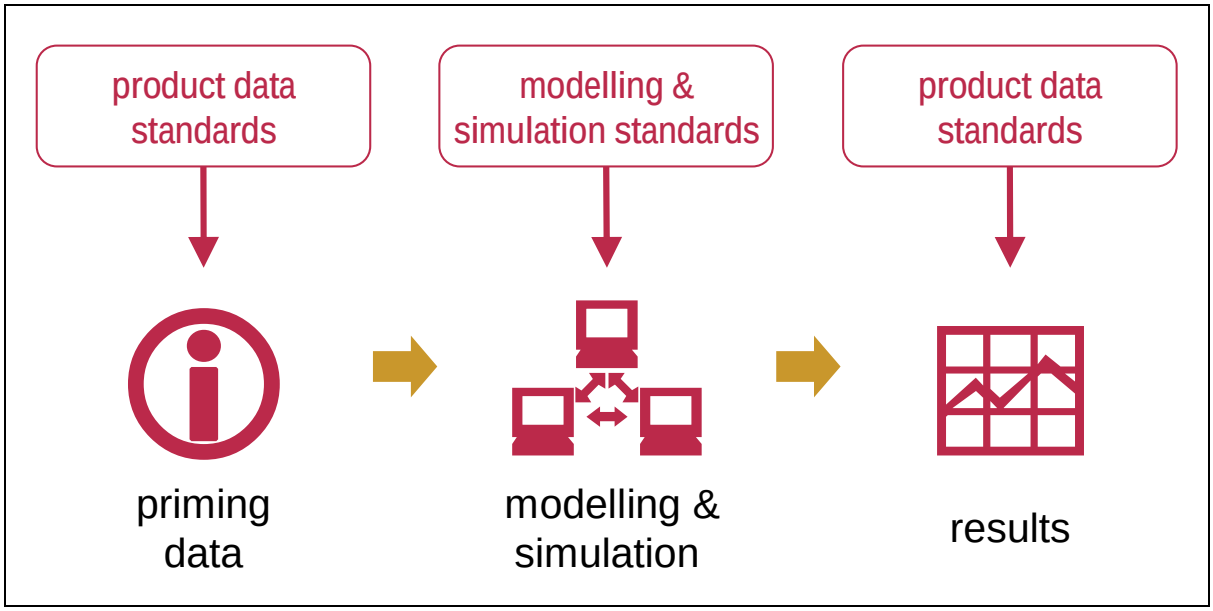


Figure 1 Integrating modelling and simulation into the broader engineering process

2 Overview

SIMBASE was a three-year research and technology project set up under the Western European Armaments Group (WEAG) in 2004 and transferred to the European Defence Agency (EDA) in 2006. The challenge for the project was to deliver a practical demonstration of SeBA/SBA. This demonstration was to investigate the following key aspects:

- a coherent and consistent approach to the acquisition process;
- effective and efficient systems engineering processes;
- software interoperability through the use of open, neutral standards;

- modelling and simulation supporting the overall engineering process.

The project participants were:

- United Kingdom (UK) MoD (Ministry of Defence), Directorate of Analysis, Experimentation & Simulation;
- MoD Italy (IT);
- MoD Norway (NO), represented by FFI (Norwegian Defence Research Establishment);
- Datamat[3] (IT), which provides expertise in synthetic environments and has previous experience of collaborative European defence research and technology projects (including WEAG RTP 11.13, "Realising the potential of networked simulations in Europe");
- Jotne EPM Technology[4] (NO), which provides a commercial toolkit supporting the ISO 10303 standard (commonly known as STEP) and has previous experience of EU-funded collaborative research projects;
- LSC Group[5] (UK), which has expertise in both logistics and systems engineering, has achieved a proven record of implementing solutions based on ISO 10303, was one of the founding sponsors of the Product Life Cycle Support (PLCS) initiative and has previous experience of EU-funded collaborative research projects.

3 Key achievements

The project has been able to achieve the following results:

- execution of a research and technology project, with strong linkage to business requirements and benefits;
- evidence of the feasibility and requirements of SeBA/SBA;
- a robust approach to systematic enterprise integration;
- application of several key technologies, including STEP, PLCS, UML (Unified Modelling Language), workflow/BPM (business process management), a synthetic environment and logistics modelling.

To this end and in line with the initial plan , the project has resulted in the following deliverables:

- the requirements, architecture and case study approach for the SIMBASE capability;
- designs for the SIMBASE repository and workflow capability;
- designs for systems engineering, logistics engineering and synthetic environment toolsets and their integration into the SIMBASE repository;
- developed software to implement the designed capability;
- a one-day demonstration of the SIMBASE capability to an invited international audience.

---

3 http://www.datamat.it/

4 http://www.epmtech.jotne.com/

5 http://www.lsc.co.uk/

The following objectives, however, were beyond the remit of SIMBASE as a research and technology project:

- detailed identification and demonstration of all the wide range of benefits from use of modelling and simulation;
- every possible application of the SIMBASE approach and technology;
- detailed explanations of all of the key technologies, with respect to end-user deployment and execution;
- production versions of all the necessary software elements.

The key intentions of the participants were to:

- strengthen the defence technology and industrial base to further develop effective acquisition processes;
- investigate the relationship between SeBA/SBA and product data standards;
- examine how these questions relate to tri-national interests and commitments.

4 Project background

4.1 SeBA/SBA

The project worked with the following core definitions:

- Synthetic Environment Based Acquisition as "… the consistent and coherent application of modelling, simulation and synthetic environment technology within, and across, both acquisition phases and programmes to facilitate the attainment of Smart Acquisition goals of faster, cheaper and better"[6];
- Simulation Based Acquisition as "an iterative, integrated product and process approach to acquisition, using modelling and simulation, that enables the war-fighting, resource allocation, and acquisition communities to fulfil the war-fighter's materiel needs, while maintaining cost as an independent variable over the system's entire life cycle and within the DoD's system of systems"[7].

Both of these terms have become better understood and richer over time, resulting in an effective equivalence between the two. Thus, the SIMBASE project has used the term "SeBA/SBA" to cover the target capability.

The overall context for the investigated capability is the extended enterprise for the complete life cycle of complex defence systems, which results in a central requirement for multi-organization interoperability. The bottom-line imperative is for projects such as SIMBASE to provide solutions addressing real business objectives, the most significant of which is ensuring the reduced total cost of ownership for the long-life, high-value assets that are typically the focus of defence acquisition programmes.

---

6 UK MoD Synthetic Environment Co-ordination Office, 2003-06-26

7 US Defense Systems Management College, 1998-12

The Ministries of Defence have conducted a wide range of investigations to demonstrate the feasibility and potential value of modelling and simulation. As a consequence, the benefit of modelling and simulation is in little doubt. However, extensive SeBA/SBA requires more than just successful modelling and simulation technology. A pan-enterprise infrastructure enables the connection between all the different parties who need to contribute to or benefit from the results of modelling and simulation.

4.2 Product data standards

The consequence of the enterprise interoperability requirement is the importance of common definitions for data to establish a language for communication and shared understanding across the enterprise. Open, neutral standards offer the compelling alternative to proprietary solutions that lock away ownership of data and pose fundamental commercial risk across the total life cycle.

With respect to such standards, the prime focus of the SIMBASE project has been STEP ("standard for the exchange of product model data"), the informal name for ISO 10303 ("Industrial automation systems and integration – Product data representation and exchange"). After more than twenty years of development, this International Standard has established the common definitions that are necessary to support a wide range of product data. The standard provides a core capability that enables the exchange, sharing and archiving of data. For SIMBASE, the most relevant part of STEP is PLCS. The PLCS initiative developed one of the ISO 10303 application protocols, AP239 (ISO 10303-239) "Product Life Cycle Support". This initiative has had commitment and participation from European Ministries of Defence and US Department of Defense (DoD).

This Executive Summary can not do full justice to all the benefits of using STEP. However, the Mars Climate Orbiter[8] provides one compelling example of how data quality issues can lead to disastrous consequences. The spacecraft failed on entry into the atmosphere of Mars and the root cause lay in one part of NASA providing a particular set of data to another part. The two teams did not have a shared understanding of the data; the providers of the data had used imperial units of measure but the receivers thought that the data was in metric units. If the two teams had used STEP then this problem would not have occurred (avoiding the destruction of the $125 million spacecraft).

The SIMBASE participants have varying degrees of experience in the exploitation of STEP/PLCS. In NO and UK, the Ministries of Defence have investigated the technology, established policy to drive adoption of the standards and started to implement systems that deliver real benefits from those standards. IT has run the CALS Italia programme to investigate and achieve the same aims.

5 Project timeline

The highlights of the project history are as follows:

- 2002
    - Industry parties identify the opportunity to explore the relationship between SeBA/SBA and product data standards;

[8] Mars Climate Orbiter Mishap Investigation Board, Phase I Report, 1999-11-10

- 2003
  - IT, NO and UK Ministries of Defence sign a Western European Union (WEU) Technical Arrangement (TA) establishing the required scope of collaboration;
- 2004
  - the WEU Research Cell (WRC) establishes a contract with LSC Group as Single Lead Industrial Entity (SLIE): Research & Technology Project (RTP) 111.011, "Simulation Based Acquisition Server (SIMBASE)";
  - LSC Group establishes sub-contracts with Datamat & Jotne EPM Technology;
  - (May) SIMBASE Project starts, with UK MoD chairing the TA Management Group (TAMG) that controls the execution of the Project;
- 2006
  - the European Defence Agency (EDA) (initiated in July 2004), takes on WRC responsibilities, the latter ceasing to exist;
  - (10 July) WRC, EDA and LSC Group negotiate a novation of the SIMBASE contracts;
- 2007
  - (15 March) SIMBASE demonstration at UK MoD Main Building;
  - (August) completion of final project deliverables.

6 Project requirements

6.1 Process context

The identified context for SIMBASE is the acquisition process that the UK MoD calls "Smart Acquisition", which embodies principles that are applicable to ongoing acquisition transformation in all WEU nations. This process encompasses true affordability, which is faster, better, cheaper, more integrated and in a context of managed risk.

The Smart Acquisition challenge is to achieve holistic, through-life systems engineering in the face of ever increasing complexity and interdependence of solution functions. The consequences are complexity and interdependence both in technical and organizational aspects of the acquisition enterprise. In turn, demonstrating affordability becomes ever more difficult. The accurate assessment of affordability is only possible with the right information of the right quality.

The SIMBASE participants identified several components to the holistic systems engineering process. ISO 15288 ("Systems life cycle processes") provides an overarching framework for these processes. Integrated logistic support (ILS) addresses the through-life support aspects of a complex system. The PLCS Application Activity Model (AAM) lays out the through-life support processes in the broader enterprise context. The Synthetic Environment Development and Exploitation Process (SEDEP)[9] provides a systematic approach to developing synthetic environments.

[9] The SEDEP was the result of the previous WEAG project, RTP 11.13, "Realising the potential of networked simulations in Europe".

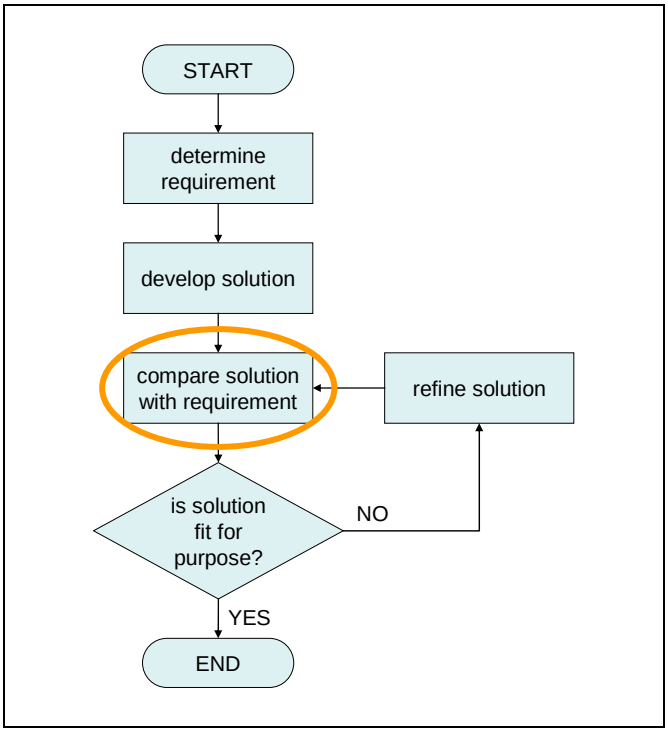


Figure 2 The fundamental pattern of developing a useful and valid system

The fundamental pattern at the heart of these processes is to compare the solution at each progressive stage of maturity and form with the applicable requirements [see **Figure 2**]. This pattern is the basis for the systems engineering "V" diagram. In traditional engineering, physical testing has been the main means by which to make the comparison of the solution with the requirements, for example measuring the achieved performance of a prototype. However, synthetic environments offer the prospect of testing the emerging solution much earlier in the acquisition life cycle. One fundamental challenge though is the extent to which the individual engineering domains remain as islands of automation; this is the problem to which the SIMBASE project has sought the answer.

6.2 The user requirement

After analysing the business context, the SIMBASE participants developed a user requirement document to express the complete possible scope of application for the intended project solution.

The single statement of user need in the user requirement document expresses the scope of the requirement: "The user shall be able to execute repeatable, best-practice business processes driven by access, throughout the life cycle, to integrated systems engineering, logistic engineering and modelling and simulation information that is applicable to any relevant phase of the solution life cycle, supports comparison of solution performance with identified applicable requirements and is consistent, coherent and independent of proprietary information management systems and other software applications."

This single statement of user need is beyond what is possible (or necessary) to deliver in a research and technology project. However, the project participants identified a solution that fits within this scope and indicates the validity of the proposed benefits achievable by a complete solution.

7 The solution architecture

Analysis of the user requirement resulted in an architecture addressing several key elements:

- "The user shall be able to execute repeatable, best-practice business processes …" led to identifying the role of workflow (business process management) in the solution;
- "The user shall be able to execute … processes driven by access, throughout the life cycle, to integrated systems engineering, logistic engineering and modelling and simulation information …" led to identifying the role of an enterprise integration toolset in the solution;
- "The user shall be able to execute … processes driven by access … to … information that is … consistent, coherent and independent of proprietary information management systems and other software applications" led to identifying the role of open, neutral standards in the solution;
- "The user shall be able to execute … processes driven by access … to … information that is applicable to any relevant phase of the solution life cycle, supports comparison of solution performance with identified applicable requirements …" established the scope of data and application toolsets that were to form the demonstration of the SIMBASE solution.

The workflow (increasingly known as "business process management") aspect of the project was important to ensure a solution that would follow the best practice already emerging from successful implementations within the defence and other sectors. This capability provides automated process administration (covering audit and escalation and reducing process timescales and the duration, effort and cost of information searches), achieves standard work (ensuring removal of errors and harmonization of training requirements), establishes cross-enterprise consistency (providing compatibility with and access to existing information sources and is complementary to applications within individual enterprise partners) and makes collaboration formal (which breaks down the cultural barriers within typical multi-organization enterprises).

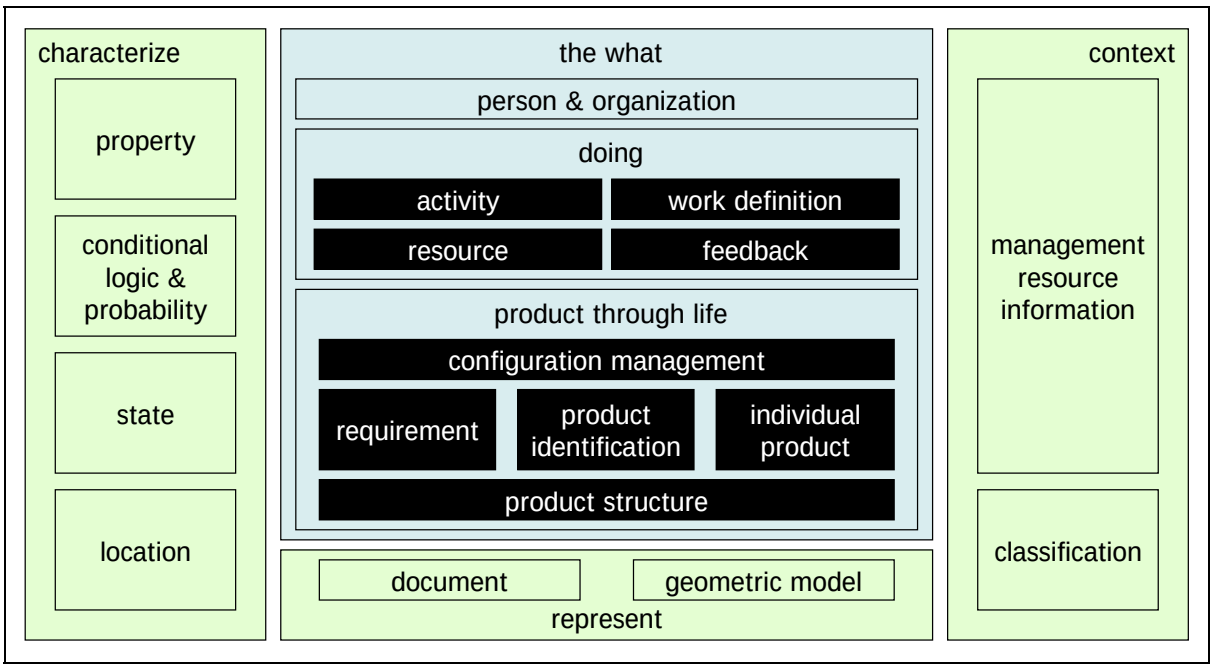


Figure 3 A summary of the PLCS data model

Although the project started with a strong expectation over the role of STEP in the solution, the participants had to review the precise details of the data scope and the available capability of different parts of the standard before being able to confirm that the PLCS data model would be appropriate for the purposes of SIMBASE [see **Figure 3**].

8 Proving the concept

In order to validate the results of the SIMBASE project, the participants had to identify a business scenario to test the processes and a set of application toolsets to implement and test the technology.

In terms of the processes, the identified scope was the individual engineering domains of systems engineering interacting with synthetic environment engineering and logistics engineering, in the context of developing a system requirement document in response to a user requirement document.

The main toolset components were commercial-off-the-shelf (COTS) tools as follows:

- for systems engineering, DOORS (from Telelogic[10]);
- for synthetic environment engineering, BattleModel (from KESEM International[11]);
- for logistic engineering, SPAR (from Clockwork Solutions[12]).

The challenge was to place these processes and technology in the context of a realistic acquisition programme that is representative of current processes and of interest for the participating Ministries of Defence. This case study was to:

- cover clearly identifiable and interesting system aspects subject to investigation by modelling & simulation;
- be adaptable without breaking the integrity of the message;
- provide existing data from the application domains within the SIMBASE project, without constraint from any security considerations over the data.

Upon considering the above requirements, the project participants identified the NATO Submarine Rescue System (NSRS) as being a suitable target acquisition programme. NO and UK are both participating in the programme and IT has interest. The UK MoD NSRS IPT co-operated in identifying and providing appropriate data sets for the SIMBASE project to use for the case study (data in the form of the user requirement document, the system requirement document and supporting analysis).

10 http://www.telelogic.com/

11 http://www.kesem.com.au/

12 http://www.clockwork-solutions.com/

9 The demonstrated capability

9.1 Process overview

Having identified the case study, the project participants then proceeded to develop a scenario that was suitable for demonstration at a public, one-day event [see **Figure 4**]. This scenario was the basis for the detailed workflow steps, placed into the workflow engine for execution.

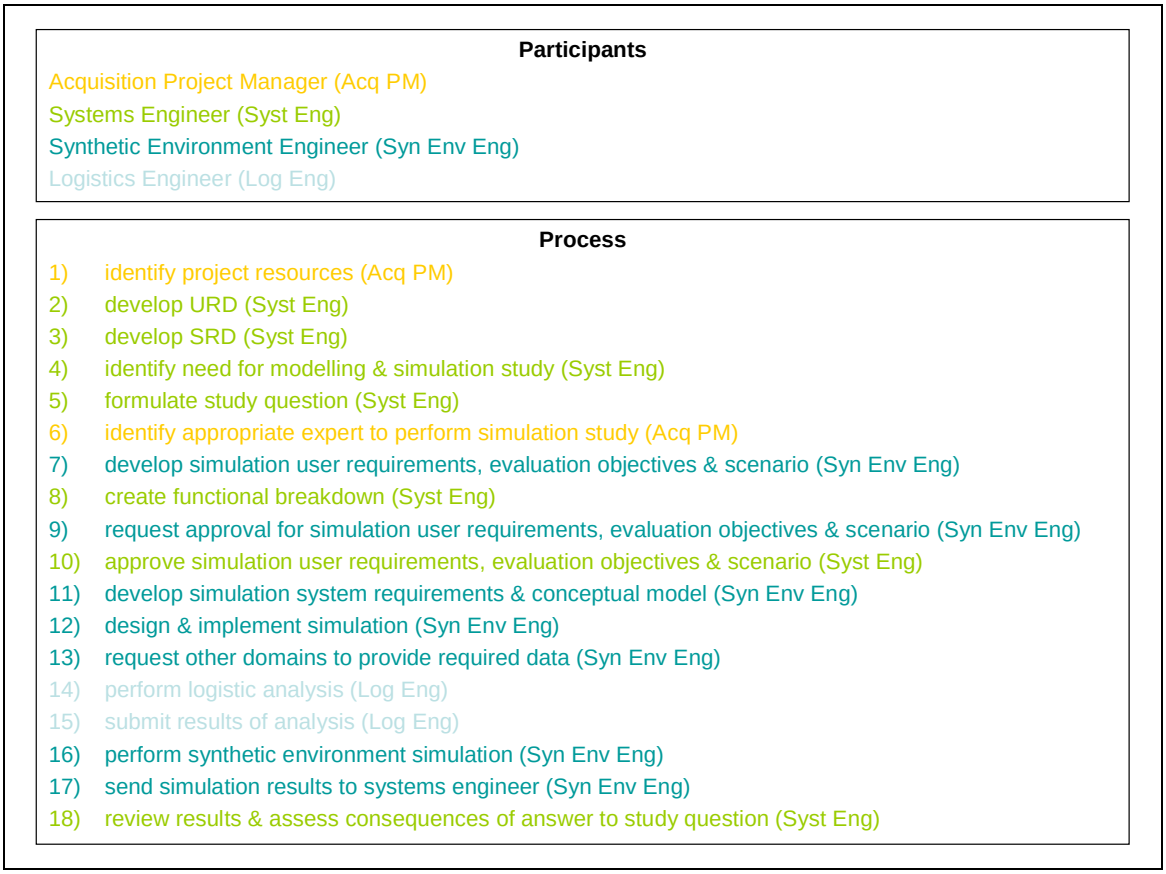


Figure 4 The content of the demonstration scenario

At each step in the workflow, a participating user is either using or creating data, often both. Data is central to the integration of the enterprise around the underlying engineering processes [see **Figure 5**].

9.2 Technology overview

At the heart of the deployed technology is a server, consisting of the enterprise repository, the workflow engine and capabilities for verify, convert and merge and query and browse [see **Figure 6**]. Some of this functionality was already available as an existing part of the COTS system EXPRESS Data Manager from Jotne EPM Technology. The SIMBASE project resulted in development of the workflow engine and some aspects of the query and browse capability.

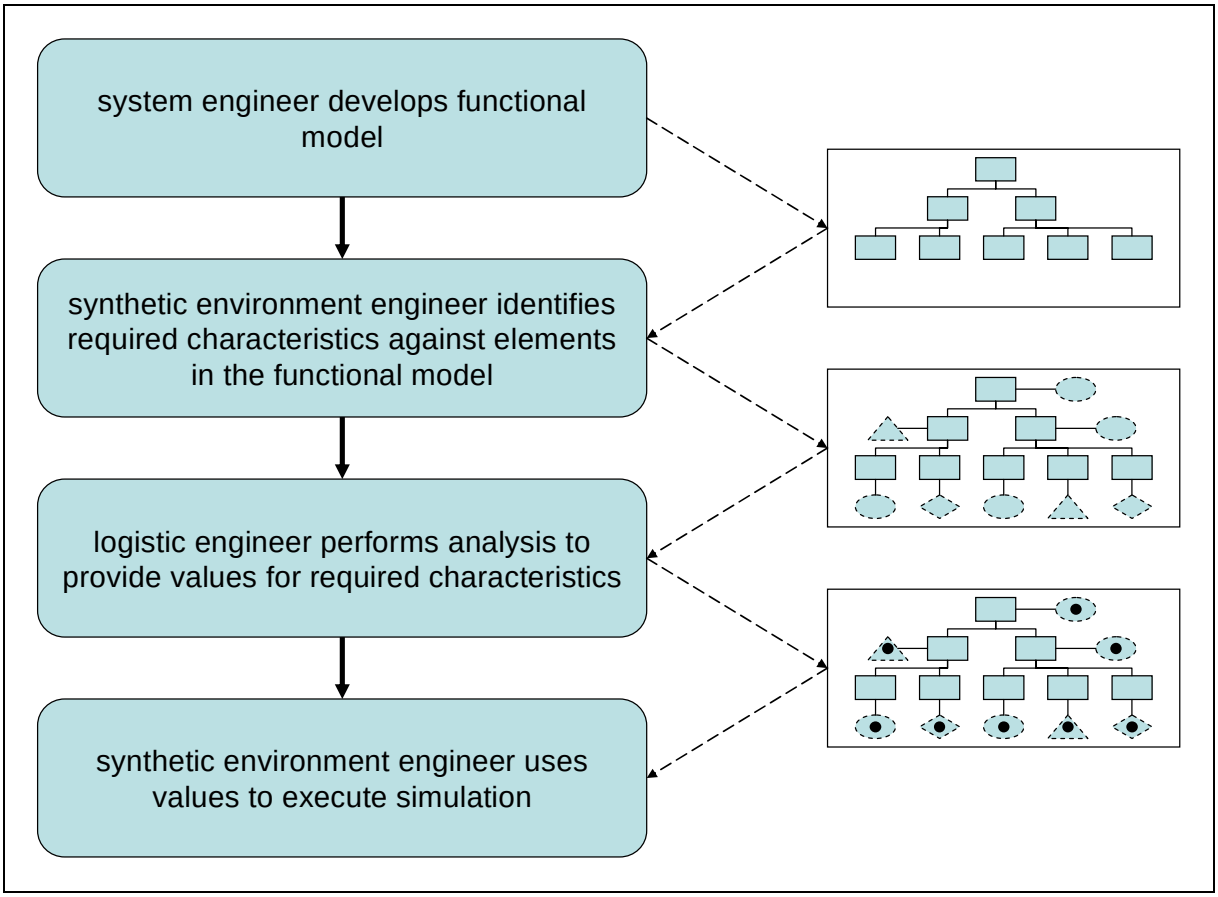


Figure 5 An example of data tying together the cross-enterprise engineering process

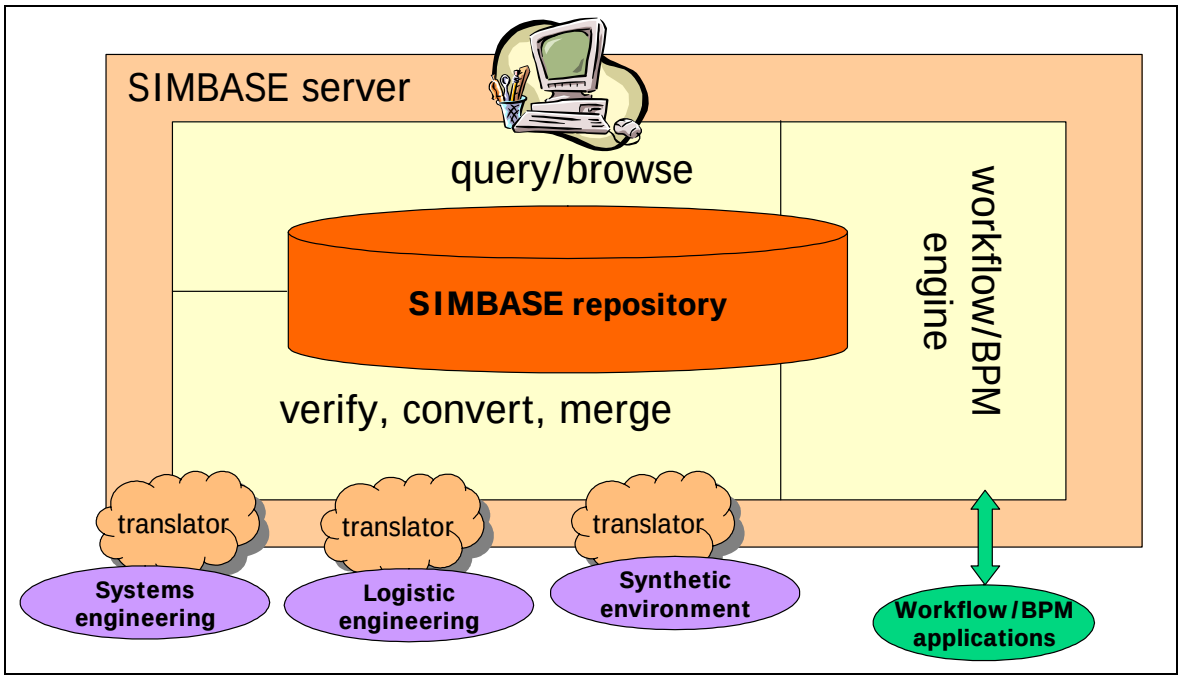


Figure 6 The software architecture of SIMBASE

The repository supports the EXPRESS modelling language as the means to specify the controlling schemas for the data. ISO 10303 uses EXPRESS to specify all schemas and, thus, the repository took on the PLCS schema without any system modification.

The project also required another major area of technical development, namely the building of interfaces between the repository and the toolsets that support the individual engineering domains. Each of these interfaces follows a common pattern to ensure a capability that is robust in delivering a validated and verified collection of data in the integrated repository (where each necessary data instance appears once and once only) [see **Figure 7**]. For SIMBASE, the integration schema is PLCS.

The SIMBASE project has resulted in interfaces from AP233 (ISO 10303-233, "Systems engineering data representation") to PLCS (exploiting an existing AP233 interface for DOORS), from PLCS to SPAR, from SPAR to PLCS, from PLCS to BattleModel and BattleModel to PLCS.

9.3 Modelling and simulation overview

The functional end of the SIMBASE project has involved the development and execution of the synthetic environment to test (virtually) the performance of the submarine rescue system. The project has not delivered a synthetic environment that has any guaranteed validity, not least because the participants have no particular expertise in submarine rescue systems.

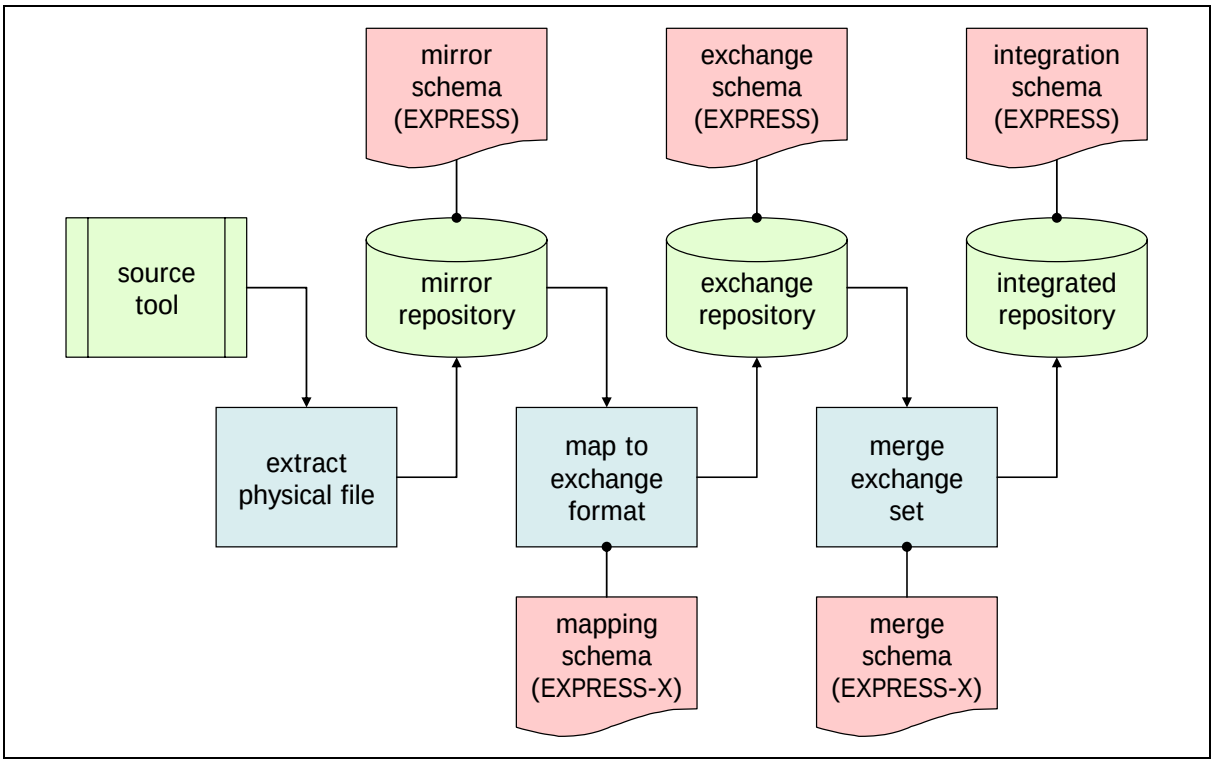


Figure 7 Translating data from domain toolsets to the integrated repository

The tested parameters of the rescue system are not necessarily those of a legitimate design option taking into account a full range of relevant factors. The principles behind synthetic environment development were all that was necessary to prove the concept of the SIMBASE solution. However, the project did generate results for five measures of effectiveness associated with the proposed system requirement:

- pre-mobilization response time;
- time to first intervention;
- time to first rescue;
- mean rescuees percentage;
- mother ship availability [see **Figure 8**].

With greater expertise in the domain of submarine rescue systems, the participants would have been able to vary the system requirement parameters and examine the corresponding impact on these measures of effectiveness. Under the control of workflow, this iteration process becomes systematic and auditable.

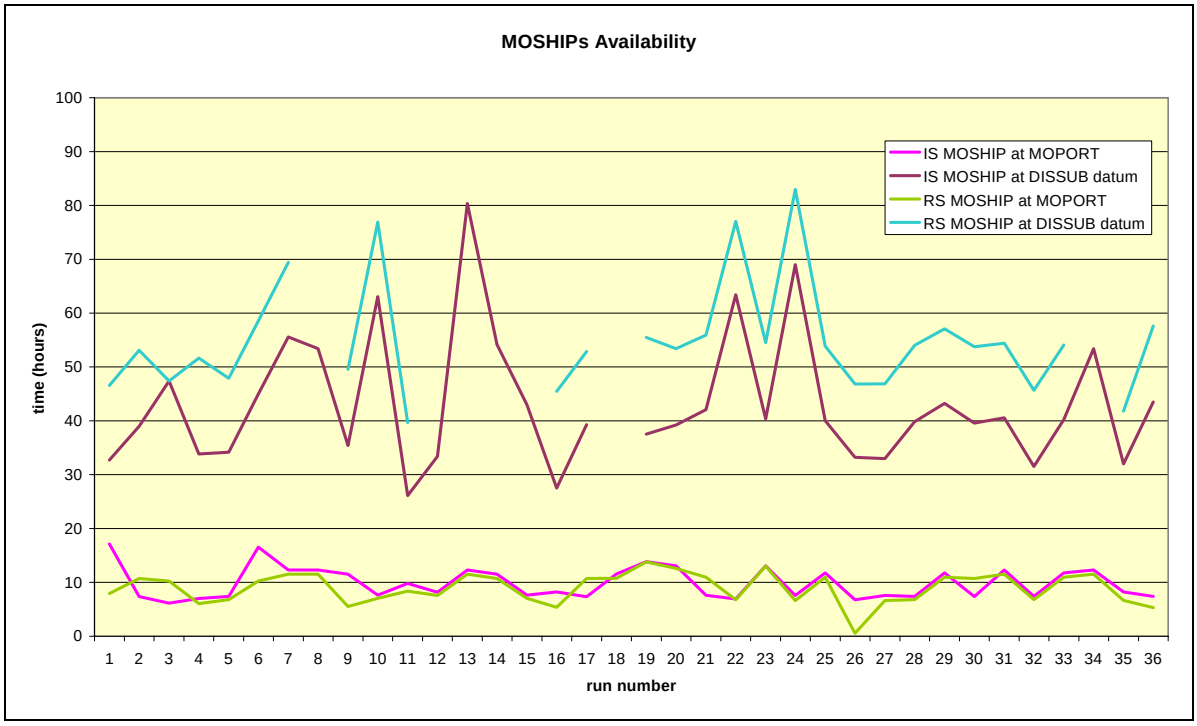


Figure 8 Example plot of mother ship availability results

10 Key project conclusions and recommendations

10.1 Practical demonstration

The demonstration event at UK MoD Main Building brought the SIMBASE project to a significant climax. Unfortunately, a major technology failure disrupted the live demonstration of the solution in the afternoon (apparently arising from COTS elements of the solution infrastructure that included a web server). At the final Management Group meeting for the project, the Industry participants were able to present the previously intended demonstration without hitch and, thus, assure the Ministries of Defence that the technology was realizable.

The original demonstration event did, however, appear to be successful in persuading the attendees (17 individuals from organizations not involved in the project, covering four different nations) that

the project had sound goals and a feasible solution approach. The scope of the project [see **Figure 9**] was sufficient to achieve this result.

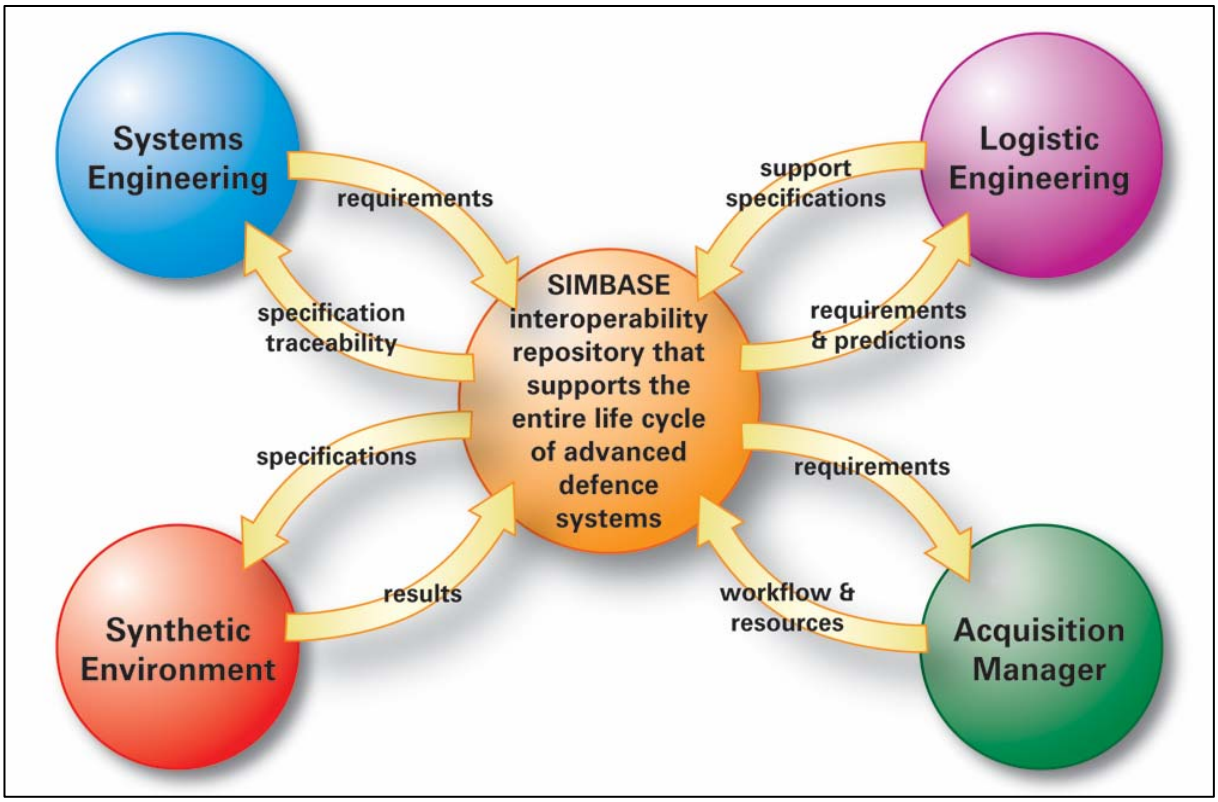


Figure 9 The core SIMBASE functionality

10.2 A new way of doing business

The project has provided evidence as to the means by which data can achieve effective enterprise integration. These data require context to be effective. Formal, explicit specifications are necessary to ensure interoperability. The specifications cover semantic and syntactic aspects of the data.

The integrated enterprise is one in which people, processes and technology become part of a structured whole. Management is effected through explicit control and accurate feedback. Instructions to the enterprise result in information returned to allow analysis of performance. The requirement is to make sure that these are structured information flows.

The vision is to move beyond current practice, where in many situations, individuals share data by e-mailing a spreadsheet. The engineering content of the spreadsheet is not an issue. However, each spreadsheet becomes an island of automation, proliferating and becoming difficult to trace when users want to identify current versions of data for use in a given activity. Workflow addresses these limitations by providing an audit trail that leads to accurate and fast searching for information. Furthermore, the spreadsheet lacks a formal semantic specification, so a human reader is necessary to resolve the meaning of a given column, perhaps having to identify the unit of measure for values in the cells. STEP moves the enterprise beyond these fundamental constraints and begins to allow structured reporting through the contents of the enterprise repository.

10.3 Project boundaries

The SIMBASE project solution has fallen within the scope of the developed user requirement but without providing full coverage. This is intentional. However, the participants are confident that the project results provide evidence of the solution being scalable to aspects such as through-life applicability. This applicability is a clear requirement in order to support SeBA/SBA because the enterprise can then benefit from systematic re-use of models and simulations. As the acquisition solution matures, one generation of model or simulation should take on the relevant content from the previous generation. In this way, one can see a route from the earliest conceptual models all the way through to simulations that, for example, support training once an acquired system is in service.

The project did not peripheral issues in any significant depth. Security is one obvious example, operating on a different level in the solution to the one at which the information integration occurs. However, EXPRESS Data Manager has been the subject of deployment in existing operational environments within the defence enterprise and has been able to meet the security challenge. The enterprise specifies the policies that determine how the server enforces access controls on all the contained data.

10.4 The next steps

The high-level recommendations of the project are:

- the Ministries of Defence should continue to support SeBA/SBA as an effective means to enhance the achievement of the Smart Acquisition aims of faster, better, cheaper;
- the Ministries of Defence should adopt the enterprise integration technologies of workflow and neutral product data standards as the basis for effective SeBA/SBA;
- the Ministries of Defence should specify the use of neutral product data standards as a contractual requirement in acquisition programmes;
- the Defence Industry should implement data exchange, sharing and archiving capabilities based on neutral product data standards, so as to provide information systems that can form part of the necessary infrastructure to support enterprise integration and effective SeBA/SBA.

The identified technology is feasible and the project participants intend to mature this technology in suitable project opportunities. In the first instance, such opportunities will not be of significant scale because the biggest challenges are likely to be cultural as much as technological and, thus, early concrete benefits will be vital to encourage adoption of the SIMBASE solution. However, major acquisition programmes will eventually be the target because the benefits will be extensive.

