

Simulation Based Acquisition – The European Way

Henk Janssen
TNO Defence, Security and Safety
The Hague, The Netherlands
Henk.Janssen@tno.nl

Jim Poelstra
Dutch Space B.V.
Leiden, The Netherlands
J.Poelstra@dutchspace.nl

LtCol. Jan Klomp
Royal Netherlands Armed Forces
Simulation Expertise Centre
The Hague, The Netherlands
JA.Klomp@mindef.nl

ABSTRACT

Due to growing complexity of systems, acquisition/procurement programs tend to grow in complexity, required effort, costs and time. It has been recognized that the way to save money and improve operational effectiveness is to shorten the time from the decision to procure products and services to the time they enter service. Simulation Based Acquisition (SBA) promises a better grip on the complexity and a reduction of procurement and development efforts, cost and time by the application of simulation. However, currently a structured approach in the application of Modeling and Simulation for Acquisition is not commonly applied and efficient tooling to support this approach has not been well identified.

From November 2005 until November 2007, 7 European countries joined in an initiative, to investigate a structured approach to SBA, to develop a Common Technical Framework (CTF) supporting this approach and to study the value of SBA

The paper starts with an introduction on current aspects and requirements on acquisition projects as experienced by the acquisition departments. The results of the initiative are presented, which provide insights into the defined approach for SBA, as laid down in the SBA process. The CTF, developed by the consortium and which supports the SBA process, is presented as the means to efficiently apply Modeling and Simulation during acquisition. The evaluation of the CTF by a realistic case on the upgrade of a Main Battle Tank is addressed and special attention is given on the identified value of SBA, taken existing approaches (US-SMART/UK-SMART) into account.

The paper concludes with findings on the use of the process and the CTF and with the way ahead on how to incorporate the SBA process and Common Technical Framework within the acquisition departments of the Ministry of Defense

ABOUT THE AUTHORS

Henk Janssen is Senior Project Manager at TNO Defence, Security and Safety in the Netherlands, with more than 20 years experience in the Modelling and Simulation field. Within the European project on SBA, Henk was in charge of the Technical Leadership of the project.

Jim Poelstra is Project Manager at Dutch Space B.V. and was in charge of the Project Management of the European SBA project.

LtCol. Jan Klomp is working at the Simulation Expertise Centre of the Royal Netherlands Armed Forces. He supports the integration of M&S standardization, processes and tools within the Royal Netherlands Armed Forces.

Simulation Based Acquisition – The European Way

Henk Janssen
TNO Defense, Security and Safety
The Hague, The Netherlands
Henk.Janssen@tno.nl

LtCol. Jan Klomp
Royal Netherlands Armed Forces
Simulation Expertise Centre
The Hague, The Netherlands
JA.Klomp@mindef.nl

Jim Poelstra
Dutch Space B.V.
Leiden, The Netherlands
J.Poelstra@dutchspace.nl

INTRODUCTION

Modeling and Simulation currently is maturing to the level that it can be used in the acquisition of advanced weapon systems. Simulation Based Acquisition (SBA) can be seen as the application of Modeling and Simulation throughout the acquisition process, from concept definition phase to the phase where the system is dismantled. Within this acquisition process all aspects of the life-cycle of a system are taken into account.

SBA promises a better grip on the complexity and a reduction of procurement and development times by the application of simulation. However, currently a structured approach in the application of Modeling and Simulation for acquisition is not commonly applied. Ref. [7] describes which aspects have to be addressed in order to leverage SBA. In general these fall into the following categories:

- Process; this in turn covers: Policy, Standards and System Engineering Environment
- Environment; this, among others, concerns infrastructure
- Culture; this concerns the collective way of thinking and resulting behavior patterns related to the utilization of SBA.

7 European countries have co-operated in a West European Armaments Organization (WEAO) initiative, designated Research Technology Program (RTP) 111.041 “Framework for Simulation Based Acquisition”, to investigate a structured approach to SBA (process), to prototype a Common Technical Framework (Environment) and to study the value of SBA.

The seven countries are:

- Norway
- Finland
- Sweden
- Denmark
- The Netherlands
- Italy
- Spain



The 2 year study started in October 2005 and ended in November 2007.

This paper will address first the challenges which acquisition departments currently face. Next a view on the acquisition processes and the preferred solution for the approach on Simulation Based Acquisition is presented (the SBA process). The Common Technical Framework (CTF), supporting the SBA process, is described in the chapter following the SBA process. The CTF proof of concept is described next, dealing also with the evaluation of the SBA process and CTF. The paper is concluded with chapters on the summary and the way ahead.

Acquisition Requirements – RTP challenge

Due to growing complexity of systems, acquisition/procurement programs tend to grow in required effort, costs and time involved. It has been recognized that the way to save money and improve operational effectiveness is to shorten the time from the decision to procure products and services to the time they enter service. In addition, the life cycle costs and

evolution of provided capabilities must be taken into account. Simulation can be an essential tool in all phases of the acquisition cycle, which covers all phases from initial concept development up to the phase where the system is disengaged.

Many Defense Organizations already apply simulation during procurement projects. For example, simulation is used to calculate the quantity of systems needed, to define functional and technical specifications and perform operational tests. In addition, it is used to study new doctrines and to provide training. Unbalanced decisions or assessments during acquisition cause risks related to the life cycle costs, operational effectiveness and even safety and security of the system's use. Therefore, it is very important to improve the traceability of data and facts on which the decisions are based.

Currently the success of using simulation often depends on individual procurement/project teams with little or no interaction with other current or past projects. Projects define their own approach and involve simulation at their own discretion. There is a growing awareness that this approach is lacking any sorts of synergy effects with the result of not being cost effective during both the procurement and usage phase. Thus, there is a need for a method of managing simulation as an asset that improves the inter-visibility between (acquisition) projects.

Constructing simulations and virtual prototypes early in the project, gives an effective way of communicating between all members of project and acquisition teams. These methods help in de-risking projects early on and in the definition of user and system requirements. Testing can also be partly done using simulation to reduce the costs of live testing. Managing the simulations and virtual prototypes during the acquisition phases in a right way, re-use is promoted which can lead to even more efficient use of modeling and simulation assets.

Finally, there exists a need to manage more efficiently the acquisition and procurement as a whole.

PROMISES OF SBA

SBA involves the use of modeling and simulation to help answer questions arising during the acquisition process.

In general SBA promises a faster, better, cheaper and better integrated acquisition of (military) systems. In more detail it promises:

- Better understanding of requirements and operational effectiveness,
- Examination of many more alternatives,
- Reduction of risk,
- Improved quality of the fielded product,
- Faster & smarter decisions,
- Reduction of the amount of live tests of the developed system.

COMMON ACQUISITION PROCESS

Several standard acquisition processes have been defined previously and are already in use, including the Concept Assessment Development Manufacturing In-Service Disposal (CADMID) process of the UK Simulation and Modeling for Acquisition, Requirements and Training (SMART) acquisition process (Ref. [3]), the US SMART acquisition process (Ref. [4]) and the NATO Phased Armaments Programming System (PAPS; Ref. [1]). However, in order to make the results of the project independent of the specific acquisition process used by a particular organization and hence as widely applicable as possible, a generic Common Acquisition Process (CAP) has been defined within the project which unifies these existing processes as much as possible.

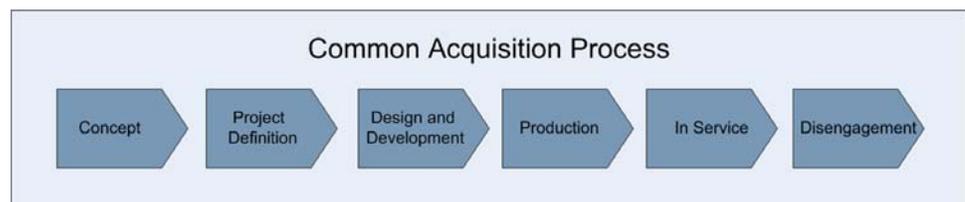


Figure 1: The common acquisition process

THE SBA PROCESS

In the course of the acquisition process, various issues and questions can arise which need to be resolved before proceeding further. Currently, existing methods for solving the questions and a range of tools, procedures and techniques for dealing with these are already in place within the national MoDs. This is

illustrated in Figure 2 by the “Existing Question Answering Process.”

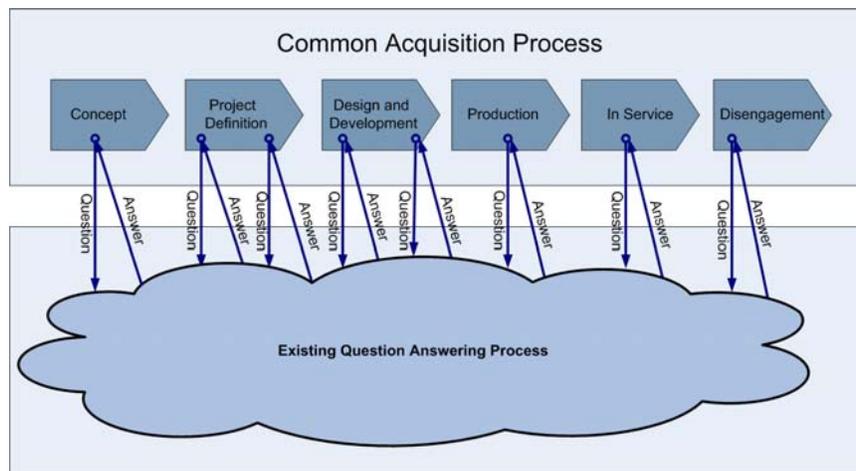


Figure 2: Current approach to answering acquisition questions

Integrating simulation with the existing question answering process

Now to integrate simulation in the existing process, the first step involves defining how simulation fits into the acquisition process at a general level. Here, the emphasis is on defining a high-level process in which the use of simulation is integrated with the existing question answering process.

A more dynamic and more flexible approach is adopted, taking into account:

- that simulation can in principle be used to help resolve issues and answer questions that arise at any point during the acquisition process;
- that even though simulation could be used to help to answer a particular question it is not necessarily the easiest or most cost-effective way of answering that question, nor is it necessarily able to provide a full answer to the question (i.e. it may need to be supplemented by other means).

In general, therefore, we view simulation as an addition to the collection of tools and techniques that can be used to answer an acquisition question, irrespective of where in the acquisition process that question arises. Thus, whenever a question arises, that question is evaluated by the team responsible for answering it and this team is responsible for deciding whether simulation is appropriate at all for that particular question and if so how it is going to be used. Also the available budget and any time constraints need to be taken into account when making these decisions.

Whenever a question or issue arises in the acquisition process, the procedure is therefore according to the SBA process depicted in Figure 3. It consists of the three steps, where emphasis is put on the two steps that are special for our SBA approach

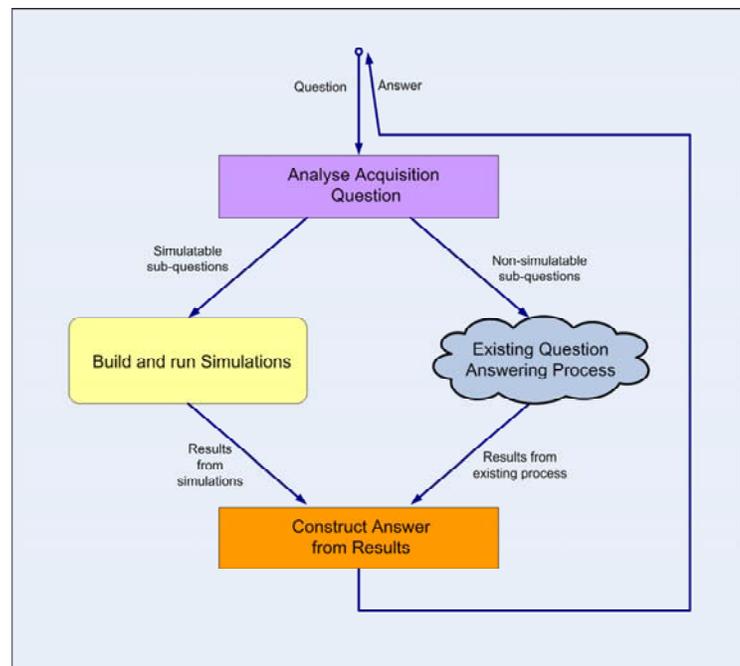


Figure 3: High-Level SBA process

Analyze Acquisition Question

In this step the acquisition question is analyzed with a view to deciding how best to use simulation to answer that particular question.

One possible result of this analysis is that it is either not feasible or not practical to use simulation to answer this question. The question must then be answered using existing question-answering processes and techniques.

Of course in the case where it is decided that it is feasible and practical to answer the whole question using simulation, there will be no non-simulatable sub-questions. And if a single simulation environment can be used to answer the whole question as it stands then the question will not be divided into sub-questions.

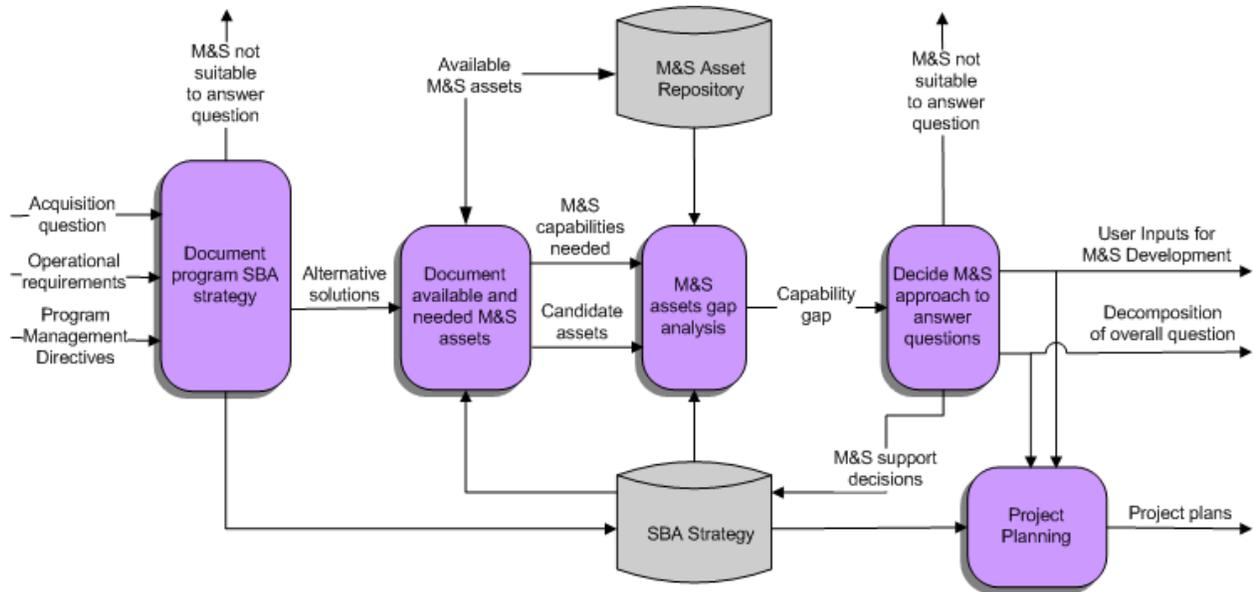


Figure 4: Detailed step “Analyze Acquisition Question”

The alternative result is that simulation can be used in some way. However, in this case it may turn out that it is only feasible and practical to use simulation to obtain a partial answer to the question and that it must be used in conjunction with existing question-answering processes and techniques in order to obtain the full answer. It may also turn out that several simulations and not just one are required. In both of these situations the question is split up into sub-questions as follows:

- a set of sub-questions that are to be answered using simulation (the simulatable sub-questions); and
- a set of sub-questions that are to be answered using existing methods (i.e. without using simulation; the non-simulatable sub-questions).

Build and run simulations

Obtain an answer to each of the simulatable sub-questions identified in step “Analyze Acquisition Question” by building and running the appropriate simulations.

Note that this “step” is in fact a whole process in its own right, starting with the definition of the requirements relevant for the simulation and progressing through its design, implementation and testing to its eventual execution and analysis of the experiment. For example, if the analysis performed in step “Analyze Acquisition Question” led to the decision that a particular simulatable sub-question would be simulated using a synthetic environment (SE), this step would in fact be steps 1 through 7 of the Synthetic Environment Development and Exploitation Process (SEDEP) as defined in the Euclid RTP11.13 project (Ref. [2]).

However, not all simulations necessarily involve a synthetic environment, and for such simulations a development process other than SEDEP might be more appropriate. In general, therefore, there could be several alternative development processes involved in this step, and the appropriate one is chosen according to the type of simulation that is to be built, which is determined as part of the definition of the simulatable sub-questions in the “Analyze Acquisition Question” step.

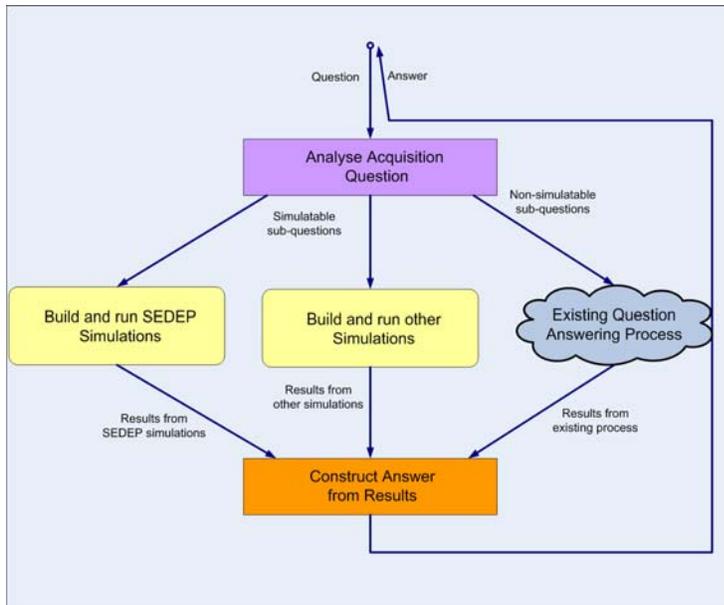


Figure 5: The SBA Process (with more detailed simulation part)

Alternative simulation development processes could be integrated into the SBA Process in the future if necessary in exactly the same way as the SEDEP process is integrated

Existing Question Answering Process

Obtain an answer to each of the non-simulatable sub-questions identified in step “Analyze Acquisition Question” by using existing tools, procedures and techniques in the usual way (i.e. without using simulation).

Construct Answer from Results

In this step the results from all the simulatable sub-questions and the results from the non-simulatable sub-questions) are collected and combined appropriately in order to construct the answer to the original question.

THE COMMON TECHNICAL FRAMEWORK

Having the SBA process defined, a Common Technical Framework (CTF) was developed to overcome the challenges as identified. This CTF provides:

- Support for a structured approach (SBA process) to solving acquisition questions, which contributes to a better mutual understanding between acquisition department stovepipes
- Managed use of Questions and answers posed / arising during the acquisition project
- Managed use of Models, simulations, simulators and Synthetic Environments, including the associated Verification, Validation and Accreditation of data, models and simulations
- Re-use of experience gained in other and earlier acquisition projects through provision of a central database (repository) amongst acquisition programs/projects.
- Capability of re-using of simulation models, simulations and Synthetic Environments through provision of a repository with search functionality within the

CTF.

- Capability of re-using of other data (scenarios, conceptual models, (federation) designs, FOMs) generated during application of the SBA process
- A collaborative environment via a web browser and local support tools to generate content for any open acquisition question.

The CTF consists of the following main functions as depicted in Figure 6.

Repository:

A storage facility holding all information needed to execute the SBA process. The repository is implemented by means of the Open Source tool Alfresco. This is a so-called Collaboration Working Environment (CWE) which allows storing information according various methods. Additionally it provides many functions to collaborate on the content, e.g. version control, workflow and categorization of content.

Asset Characterization Tool:

A facility which allows recording simulation asset characteristics in a well structured and standardized manner

Process Browser:

A facility which provides descriptions of each of the process steps in the SBA process.

Process Status Monitor:

A utility which visualizes the status of the execution of individual SBA process steps/activities

Templates:

A collection of templates which provide a standardized outline and content for the most commonly used data files and for all data file collections.

Help:

A collection of texts providing explanations or instructions on how to execute the activities in the SBA process and use the CTF and/or individual CTF elements.

Process support tools:

A collection of tools which supports the execution of activities according to the SBA process. This is a collection of COTS tools which is installed locally. As examples, the following tools are identified to support the SBA process: DOORS™ (Telelogic), MS-Office® (Microsoft Corporation), MS-Project® (Microsoft Corporation), the CASE-tool Enterprise Architect^(C) (Sparx Systems Pty Ltd), the HLA federation development support tool SIMplicity® (Calytrix), the mathematical computation and analysis tool MATLAB® (The Mathworks).

Selected tools to support the SBA process can easily be exchanged with other tools, because the tools are not integrated with the Common Technical Framework. The file formats used for exchange of information between the different process activities/steps rely on the native interfaces of the selected COTS or Open Source tools. For re-use purposes it was decided to have native formats of tool output also in readable MS-Word or XML format, in case another tool application is selected for supporting the respective process step. Where no dedicated tool support is available for specific process activities/steps the default file format is MS-Word. In most of these cases a template is available which defines/specifies the outline and content of the documents to be produced and exchanged.

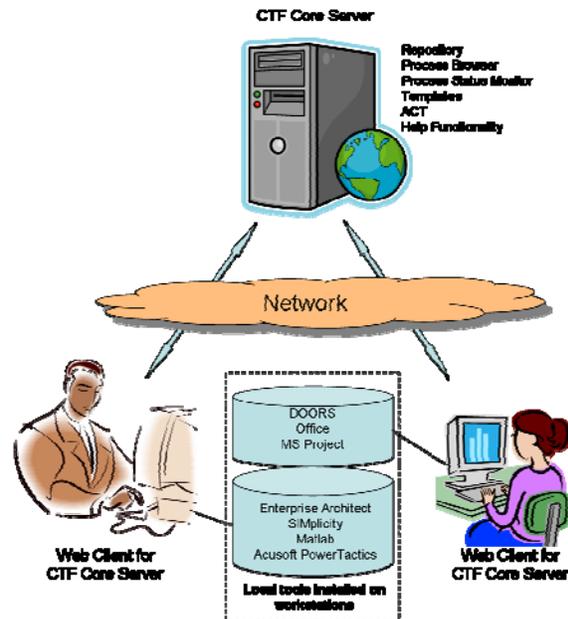


Figure 6: View on the Common Technical Framework

PROOF OF CONCEPT

For testing and evaluation of the SBA process and the Common Technical Framework, showcases were developed of an acquisition scenario of a near-future upgrade or replacement of a Main Battle Tank:

The main acquisition question posed for the showcases is:

What to upgrade in the main battle tank (MBT) in order to satisfy the mission needs that will enable success in current and future peace support operations.

With the help of the Quality Function Deployment method (Ref. [8]), three example acquisition questions were identified for being solved by using the CTF.

For two of the three cases, the Analyze Acquisition Question step resulted in building distributed federations according to the SEDEP and having simulation assets available. The remaining case resulted in development of a stand-alone simulation application.

The following acquisition questions were identified and chosen as case for solving using the CTF

Acquisition question 1: Is a Route Planning System a solution to improve the NEC?

For this question put into the Analyze Acquisition Question Step, a standalone simulation model was developed simulating the effect of route planning to

tactical radio coverage and to the exposure to hostile units. It was concluded in the experiments against a baseline route in the scenario, that route planning does improve the NEC capability.

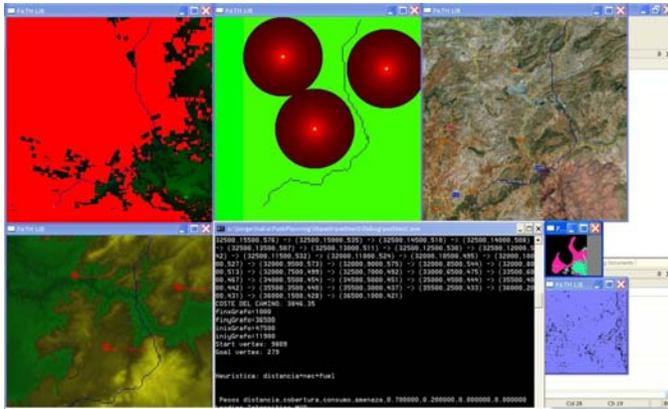


Figure 7: Route planning simulation application used in the acquisition question on the Networked Enabled Capability improvement. (INDRA)

Acquisition Question 2: How can lethality be improved in a Platoon of Main Battle Tanks?

Lethality is a broad concept where several factors are contributing in specific contexts, in order to cut clear in what way lethality can be augmented, specific weapon systems mixes where selected with the intent of investigates function of these as part of a suggested MBT upgrade program in specific scenario.

This led to the refinement of the acquisition question to: *How will a mix of Weaponry and Ammunition improve lethality in a platoon of Main Battle Tanks?*

Using the results of the Analyze Acquisition Question step a combination of two simulation assets into a composite asset seemed to be the most appropriate solution

- CATS simulation asset, constructive simulator providing required CGF functionality.
- AVAL simulation asset, high detail engineering vulnerability and lethality simulation. This asset resolves effect on target.

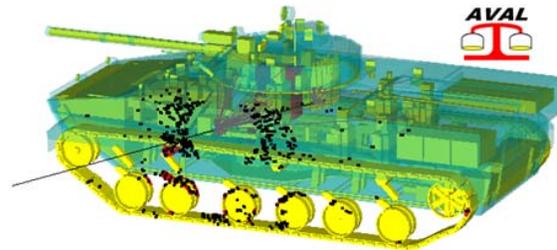


Figure 9: MBT representation and shell detonation in the Assessment of Vulnerability And Lethality model (BAE Systems)

The experiments using the federation resulted in a favorable configuration of ammunitions for the specified scenario

Acquisition question 3: How will upgrading the MBT with a remotely controlled weapon system affect the operational effectiveness of the MBT in urban areas?

The Analyze Acquisition Question step resulted in a solution of a Virtual Simulator to assess the MOPs and MOEs within the missions/scenarios defined. In addition an Offline Tool is proposed for calculating MOEs.

A federation, consisting of available mockups representing a Leo2-A5 and a Remote Weapon Station Training simulator were integrated in short time with support of the CTF.

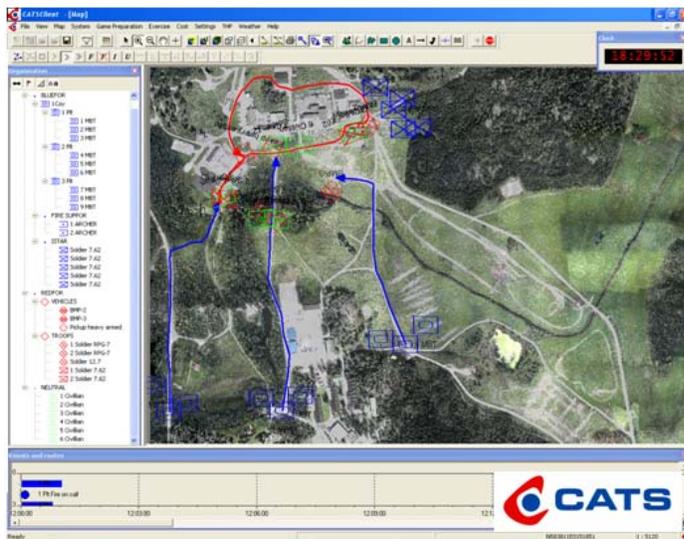


Figure 8: Screen of CATS simulation model (BAE Systems)

One of the feedbacks from the Leopard 2 crews participating in the experiment analyzing the consequences on the operational effectiveness of a Leopard 2 A5 with and without a Remote Weapon Station said: “These kinds of experiments and environments are suitable to prove the extended capabilities of weapon systems, or at least get a good feel of it.” This indicates that simulation was a good choice for answering the selected question.



Figure 10: Screenshot during the performance assessment of the Protector Remote Weapon Station (Kongsberg Defense & Aerospace) added on the Leopard-2A5 Main Battle Tank simulator (TNO) for operations in urban areas.

Evaluation of the SBA process

There are a number of existing approaches to supporting the acquisition process using simulation, and a number of examples of their application on specific acquisition projects.

UK SMART (Ref. [3]) and US SMART (Ref. [4]) are the best developed and also the most widely applied of the existing approaches. Both are based around the idea of planning in advance exactly how simulation is going to be used on each particular project (for UK SMART by defining the strategy for using modeling and simulation on the project, then the plan for implementing that strategy; for US SMART via the development of a simulation support plan for the

project). As a result, applications have tended to concentrate on a specific aspect of the acquisition process, such as the evaluation and comparison of responses to requests for quotation (RFQ) or reducing the amount of live testing required.

Although acquisition organizations recognize the value of simulation as a tool to help them answer acquisition questions and are keen to make use of it, this has to be done within the framework of their existing acquisition process because it is too expensive to change this in any significant way. The SBA Process has been designed with this very much in mind.

The SBA Process therefore makes no assumptions about the acquisition process. It simply inserts new process steps between the acquisition process and the question answering process, one in each direction, and defines these steps in a way which is independent both of the acquisition process and of the particular phase in the acquisition process at which the acquisition question arose.

In addition, it treats simulation as just one of many tools and techniques that can be used to answer an acquisition question: all of these techniques, including all the existing ways of answering acquisition questions without using simulation, are potentially useful, and the one that offers the best

results for the particular question is the one that should be chosen.

The purpose of the first step in the SBA Process, “Analyze Acquisition Question” (AAQ), is therefore to decide how best to answer a particular acquisition question – whether to use simulation, existing question answering processes that don’t use simulation, or a combination of both – and the process description includes a detailed explanation of what activities need to be performed and what needs to be taken into account within this step in order to make this decision. And the return step, “Construct Answer from Results” (CAfR), collects and coordinates all the results in the case where the question is answered using a combination of techniques and/or several different simulations, and again the process description includes a detailed explanation of what activities need to be performed in order to do this.

The SBA Process can therefore be integrated extremely smoothly with an acquisition organization’s existing procedures, irrespective of exactly what those procedures are – the acquisition process and all the

techniques currently used to answer acquisition questions remain in place exactly as they are.

This structure also means that the SBA Process offers a highly flexible approach to answering acquisition questions. Each question is analyzed and evaluated in its own right with a view to determining how best to answer it with the resources and information that are available at the time the question arises. This ensures that simulation is always used to its best effect for each individual question throughout the acquisition process.

The SBA Process is also structured so as to make it very easy to extend with new methods for answering acquisition questions, irrespective of whether those methods are specific methods for developing simulations or whether they are unrelated to simulation – the new process steps Analyze Acquisition Question (AAQ) and Construct Answer from Results (CAfR) form a framework around the question-answering process, with AAQ acting as a decision gate in which the best method for answering each particular question is determined, so the new method can be incorporated by simply extending the description of AAQ to include information about how to assess the effectiveness of using the new method together with guidelines on when to use it.

The detailed descriptions of the two new process steps, particularly that of the Analyze Acquisition Question (AAQ) step, have been refined and improved throughout the course of the project, based not only on feedback from the customer but also on experience gained from the three demonstration questions, each of which was analyzed by working through the AAQ step in detail. The use of AAQ in the analysis of the three demonstration cases has also served to demonstrate, albeit to a limited extent, that the SBA Process is practicable.

Evaluation of the Common Technical Framework

By evaluating the CTF with three acquisition questions, the following can be concluded:

- The associated SBA process provides a firm foundation for the CTF. The SBA process has shown to integrate very easy with any acquisition process or procedure
- The CTF is a means to share knowledge across acquisition programs and acquisition questions.
- The CTF is a growing database of simulation models for re-use.
- Enabling re-use of M&S assets by use of repositories is a key element for cost and time savings in SBA.

- The CTF provides a good framework for collaboration when building (distributed) Synthetic Environments.

SUMMARIZING

The RTP 111.041 has developed a product in the form of the Common Technical Framework (CTF) which provides the infrastructure for a structured, simulation based approach to acquisition:

- The CTF is a step forward to achieve a common know-how of performing Simulation Based Acquisition and M&S experimentation in Europe. This know-how includes, not only the process but also the way and means to characterize assets, how to document the results of all activities, the means of archiving and share this information in a repository in order to reuse all this knowledge in future questions, even across acquisition projects.
- This first released version of the CTF is on sufficient level of maturity such that it can be used in operational acquisition programs in order to receive feedback from new users posing new questions into the system.

THE WAY AHEAD - CHALLENGES

What remains is addressing the culture of the acquisition organizations. The main priority is to provide evidence that SBA promises are fulfilled by means of simulation, or in other words make it popular such that the MoDs adopt SBA and continue to implement it in a more structural manner.

Because the definition of the SBA process is independent of the acquisition process, the introduction of the process into an acquisition organization requires only the implementation of the two new process steps Analyze Acquisition Question and Construct Answer from Results – all the acquisition organization's existing processes remain in place exactly as they are now.

Suitable, real acquisition projects in which simulation could play a role can then serve as pilot projects for the introduction of the new process steps and the Common Technical Framework into the acquisition organization.

It is therefore recommended to start pilots on using the CTF in a real acquisition environment and with future users involved. This promotes that the SBA process and the CTF will be embedded in the procurement departments of the MoDs in the future.

For having the SBA approach and CTF fully accepted by the MoDs, there still exist some challenges. The SBA approach requires teaming with industry early on during the acquisition phase. Each question can result in different teams, based on the use of most appropriate assets for solving the acquisition question. So the challenge of getting teaming agreements and contracts in place in due time is to be considered.

The SBA approach and CTF promotes re-usability of simulation assets, which can only be established by a large repository of asset descriptions. A challenge is to have this repository updated by the asset owners which have to provide data to the repository and keeping those data up to date.

As the first country and lead nation of the ERG 111.014 initiative, the Netherlands Ministry of Defense currently develops initiatives for the application of the SBA process and CTF in pilot projects at their acquisition department. Furthermore the European Defense Agency has indicated interest in supporting and hosting the CTF and its repository if countries initiate mutual efforts in this area. Such a multinational use of the CTF would result in a large acquisition knowledge base and repository, boosting Simulation Based Acquisition into the future.

REFERENCES

- Ref. [1] Handbook on the Phased Armaments Programming System (PAPS). NATO. February 1989.
- Ref. [2] <http://euclid1113.com>, SE Development & Exploitation Process (SEDEP) v2.0
- Ref. [3] <http://www.aof.mod.uk/index.htm>
- Ref. [4] <http://www.amso.army.mil/smart>
- Ref. [5] "The New SBA Revisited", Joe Von Holle, February 24, 2004, http://www.msiac.dmsomil/sba_documents/TheNewSBA_Revisited-final-022404.doc
- Ref. [6] http://www.msiac.dmsomil/sba_documents/SEC6-ROI.pdf
- Ref. [7] Implementing SMART in the US Army through Simulation Support Plans
- Ref. [8] Guinta, L. R. and Praizler, N. C. The QFD Book, The Team Approach to Solving Problems and Satisfying Customers Through Quality Function Deployment. AMACOM Books. 1993.

ACKNOWLEDGEMENTS

The authors would like to thank all participants of ERG111.041 "Framework for Simulation Based Acquisition" for their contributions and achievements to the project which have resulted in this paper. The authors would also like to extend their thanks to the national representatives in the Management Group for their comments, guidance and support during the study.